EPIDEMIOLOGY AND ECONOMIC IMPACT OF ROAD TRAFFIC ACCIDENTS IN THE UNITED ARAB EMIRATES

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I certify that this thesis is the true and accurate version of the thesis approved by the examiners.

Signed [redacted]...
(Director of Studies)

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ABSTRACT

High rates of serious road traffic accidents (RTAs) have been reported for the United Arab Emirates (UAE), in recent years. This research aims to describe the problem in the UAE and to quantify its economic burden on the country's resources.

The approach chosen is quantitative, based on methods of RTA epidemiology and economic evaluation. The research is carried in two parts. Part one attempts to identify trends of morbidity and mortality from RTAs during 1981-1995, to compare the magnitude of the problem with other countries, to evaluate information available on possible causes, to estimate future forecasts of the problem and to analyse RTA injury severity before and after enforcing seatbelt legislation. The results of part one provide the basis to evaluate the economic impact of the problem during 1995 and to estimate the rational investment levels for improving safety and health, in part two. The Human Capital (HC) approach is used to estimate the economic costs of RTAs in the UAE during 1995. To estimate RTA comprehensive costs the study adds to the latter the costs of pain, grief and suffering (PGS) to RTA victims, drawn worldwide, using the Willingness to Pay (WTP) value approach.

Data were obtained from police, health and WHO sources to describe trends in morbidity and mortality from 1981 to 1995. The results revealed that during the period 1981-1995, the rates of RTAs per 100,000 population and per 100,000 motor vehicles declined in the UAE by a trend component of -96.5 (p<0.001; R^2=0.69) and by -522 (p<. 001; R^2=0.92) respectively. RTA specific fatality rates based on the same two denominators also declined by -1.1 (p<. 02; R^2=0.56) and -5.1 (p<.02; R^2=0.330); and injury rates declined by a trend component of -6.8 (p<. 01; R^2=0.341) and -28.0 (p=n.s.) respectively. Paradoxically, however, except for a short period (1981-1985), a steady increase in the risk of injury and death in each RTA accompanied these declines. Between 1985 - 1995 the severity rate of RTA injuries more than doubled (p<.001). The UAE's specific fatality rates per 100,000 population and per 100,000 motor vehicles were high when compared with other countries. The reason for the increasing severity is not clear, but drivers aged between 18 and 40 years were mostly implicated in fatalities. When injury severity was measured before and after the enforcement of seat-belt legislation in

1999, a significant downward trend in injury severity occurred when seat belts were worn (chi-Square = 77.68, $p<0.0001$).

The total economic cost of RTAs in the UAE during 1995 amounted to AED 3.8 billion, equivalent to US$ 1 billion, representing 2-3% of the annual GDP. Out of that, the direct monetary costs of RTA fatalities and injuries exceeded AED 1 billion while the indirect costs accounted for the rest. The comprehensive costs of RTAs in the UAE amounted to AED 11.4 billions and ranged from AED 50,000 per minor injury to AED 7.5 million per fatality, roughly 4 times the economic costs of these events. This indicates that it is rational public policy to invest up to AED 50,000 to enhance safety and health to prevent one minor injury and up to AED 7.5 millions to prevent one death.

The thesis makes many recommendations to improve future epidemiological and economic analysis of RTAs in the UAE. It is hoped that this study will form a useful base for evaluation when these studies take place and for establishing cost benefit ratios and, therefore, priority for future prevention strategies.

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PREFACE

This thesis was written while the author was employed as an administrator in the Department of Community Medicine at the United Arab Emirates University at Al-Ain in the United Arab Emirates (UAE). Since most of the faculty personnel did not speak Arabic one of the functions of the administrator was to act as interpreter during such necessary routine functions as organising the community based research of the department with the authorities. It had been noted that road traffic accidents were the second cause of death in the UAE (MoH reports: 1981-1996). Since this constituted a major Public Health problem it seemed appropriate for the Community Medicine department to research this area. Access to appropriate material was not easy and the author was involved in negotiations with officials of the Police Directorate with whom he developed a rapport as a result of his administrative responsibilities. There was little initial interest in research and it was felt that a reasonable first step would be to offer to teach first-aid to traffic policemen as a means not only of improving survival on the roads but of gaining access to research material. This offer was accepted and once again the author was very much involved because the policemen found difficulty in being taught in English and he acted as interpreter. The first course was a considerable success and many more followed so that the author was eventually able to conduct the courses in Arabic with little prompting and he gained an understanding of the medical problems of road traffic accidents. He was thus able to co-author an Arabic text to be used in the courses (Norman and El-Sadig, 1996). The rapport with the Police Directorate had now developed to such an extent that ready access was allowed to the records and statistics necessary to undertake an epidemiological study of road traffic accidents in the UAE. The author was entrusted with this study by the senior members of the Community Medicine Department (Appendix 9). Through, the author attended two courses: the first was a distance learning programme on Principles of Epidemiology, organised and sponsored by the U.S. centre for Disease Control, Atlanta-Georgia, in 1996 and the second was on Safety Promotion Research, organised by Karolinska Institute, in Stockholm, Sweden, in 1999 (Appendices 6 and 7). When that part of the study was nearing completion future development could have led in many ways. The author's primary qualification was, however, in economics so the second part of the study was designed to take account of the cost of road traffic accidents to the community. The ultimate aim of this research is to reduce the cost of road traffic accidents to the community of the UAE both in terms of money and also in terms of human suffering. The research undertaken suggests various directions in which this could be achieved and many of these have been suggested to the appropriate authorities in the UAE. The main contribution which it is hoped this study will provide, however, is to act as a base line against which both current and future attempts at improvement can be measured and prioritised.

CHAPTER 1
INTRODUCTION

1.1 Global Background to the Problem of Road Traffic Accidents

The risk of material damage, injury, incapacity and death posed by the widespread use of motor-vehicle transportation in most countries in the world is significant. Evidence is accumulating to suggest that mobility through roadway transportation carries the greatest risk per unit time of any activity for accidental death and injury; and as such it probably constitutes the single largest source of health burden, to individuals, societies and nations world-wide. The First World Conference on Accidents and Injury Prevention in Stockholm 1989 declared that the true social and economic burden of accidental injuries was only partially understood by governments and the public (World Health Organisation (WHO) and Karolinska Institute, 1989). It revealed that, globally, nearly three million deaths were reported from injury and poisoning each year throughout the 1980s; over two million of these occurred in developing countries. Moreover, it showed that, worldwide, up to one third of all hospital admissions resulted from injuries and almost 60% of these were due to road traffic accidents (RTAs) (WHO and Karolinska Institute, 1989). Participants revealed that such admissions are costly because of the demands they make on health services for emergency, diagnostic and therapeutic care, rehabilitation and lifelong assistance to achieve optimal social functioning. According to the data, the annual economic costs of injuries, lost productivity of workers and medical and social costs were estimated to exceed US$ 500 billion worldwide (WHO and Karolinska Institute, 1989). To this cost must be added the social and psychological costs of permanently disabling conditions for the injured individuals and their families.

Worldwide, the increasing impact of RTAs over the last five decades, especially in developed countries, has raised considerable concern and attention. This concern was inevitably converted into organised research and government intervention (Haight, 1994; Andressend, 1985; Bener *et al.*, 1994). Research has used the methods of epidemiology on one hand and economic evaluations on the other (Haight, 1994). Epidemiology is the science of studying the occurrence, distribution, causes and prevention of diseases (Farmer et al., 1995). RTA epidemiology is a new sub-discipline with a theoretical basis stemming from the wider discipline of epidemiology. The sub-discipline concentrates on developing epidemiological tools and models for identifying RTA consequences, defining their trends, determining the causal factors contributing to them and proposing what safety measures could be elaborated for preventive purposes (Haight, 1994). Although most studies that applied the sub-discipline of RTA epidemiology failed, due to data limitations, to quantify exactly the effect of every specific factor contributing to RTAs, they did succeed in identifying the aggregate changes in secular trends of RTAs by analysing changes in certain parameters, using the data systematically collected by police authorities, medical districts and insurance companies (Haight, 1994).

An integral part of the analysis of the RTA problem is the quantification of its economic impact on society. The purpose of the analysis is to establish the cost effectiveness and the cost benefit ratios to set priority for future roadway safety programmes and projects. It is now the practice to estimate the economic impact of RTAs at regular intervals in most developed countries (Elvik, 1994).

These efforts have helped in understanding the size of the problem and have enabled policy makers to mobilise more resources to reduce RTAs; an effort that eventually led to minimise the scale of the problem in most developed countries.

1.2 Background to the Problem of RTAs in the UAE

The United Arab Emirates (UAE) has experienced rapid economic development over the last 40 years following the discovery of oil in Abu Dhabi Emirate in 1958. Prior to the first oil exports in 1962, life for inhabitants of the region had continued largely unchanged for more than 1000 years (Al-Talib, 1985). The economy was subsistence one, based on pearl fishing and trade, camel breeding and oasis farming. Following the global oil crisis of 1973 and 1979, the UAE witnessed rapid economic growth within a few years, which led to the transformation of the economy into a developing market economy (Shanks, *et al.*, 1994). For example, while the contribution of farming and fishing to gross domestic product (GDP) grew from 0.7% to 1.6% between 1975 and 1990, the contribution of the manufacturing industries to GDP increased from 0.9% in 1975 to 17.7% in 1990. Transportation and storage grew from 3.0% in 1975 to 9% in 1990 and Insurance and Financial Services from 1.6% to 4.1. Although, oil and gas still plays a crucial role in the UAE economy its relative importance declined from 67.5% in 1975 to less than 50% in 1990, reflecting the increasing diversification and structural change in the UAE. Overall, the UAE economy grew at an average rate of 16% per annum during the 1970s before levelling to an average of 4.2% throughout the 1980s (UAE-ASA: 1975-1995). Accordingly, per capita income increased from minimal levels in 1970 to reach US$ 13,850 in 1985 and US$ 16,500 in 1995.

These patterns were accompanied by an influx of expatriate workers. As a result, the relatively small population of the UAE increased annually by 10.2% between 1977-1998 (UAE Annual Statistics: 1975-1998). Subsequently, the number of registered motor vehicles increased annually by 28.1% (UAE Annual Statistics: 1975-1998). Also, the length of paved highways, inter-city roads and rural roads increased by more than 8 fold during the period 1980-1995.

These developments influenced and changed the lifestyle of people in the UAE. The traditional modes of transportation, the camel and the *Dhow* boat, which formed the only means of transportation for years, were replaced by modern modes, mainly roadway motor-vehicle transportation. At present it is estimated that 90% of passengers and freight go by road in the UAE.

However, though roadway transportation has brought improvements to the UAE people's life, in terms of flexibility, choice and satisfaction, it has brought adverse consequences including pollution and RTAs. Rising numbers of RTAs and consequent increases in injuries and fatalities accompanied these changes. According to official reports the RTA problem is now the second cause of death in the country and possibly the leading cause of serious injury, disability and premature death among adults (Ministry of Health (MoH) Annual Report, 1998). In 1998, in a population of approximately 2.7 million, 10,127 people were injured, of whom 646 (6.4%) died (MoH Annual Report, 1998). Hence, the problem constitutes a major concern for public health and a sizeable burden to the UAE's health care resources.

Pic.1: Traffic accidents in the UAE

Pic.2: Roads in the UAE

Although the Arabian Gulf countries, including the UAE, have significantly higher rates of morbidity and mortality due to RTAs than developed countries, contrary to the experience in those countries, little has been done yet to establish the baseline facts about the problem in Gulf countries, a step which is essential for plans aiming to prevent RTAs and to control their lethal outcomes.

1.3 Aim and Objectives

This research aims to determine the baseline facts about the problem of RTAs in the UAE and to quantify, in monetary terms, its impact to the country's societal and health care resources.

The approach chosen is quantitative; based on methods of RTA epidemiology and methods of economic evaluation and the research is carried in two parts. Part one attempts to identify trends of morbidity and mortality from RTAs during 1981-1995, to compare its magnitude with other countries, to evaluate information available on possible causes, to estimate future forecasts of the problem if nothing has been done to control it and to analyse RTA injury severity before and after the enforcement of seatbelt legislation in the UAE. The results of part one provides the baseline facts about the problem in the UAE on the basis of which the quantification of its economic impact is be made and the effectiveness of roadway traffic safety interventions is evaluated, in part two.

Part two aims to quantify the economic impact of the problem of RTAs in the UAE, during 1995, through assessing the direct and indirect economic costs of morbidity and mortality, in addition to property damages caused by RTAs. This includes assessing and measuring workplace and household productivity losses from RTAs, medical costs to victims, emergency services costs, insurance and police administration costs, employer workplace costs, legal and court costs and property damage costs. Also the study attempts to place value on human pain, grief and suffering (PGS) sustained by casualties and their families and to measure decreases in social well being due to the RTA problem in the UAE.

1.4 Policy Implications and Future Utilisation

The results of the study are expected to provide to policy makers the baseline facts of the problem of RTAs and its future trends in the UAE. That is in addition to a sizeable body of information on rational investment levels of roadway safety in the UAE; a data, which is essential to establish the cost benefit ratios and, therefore, the priority in conducting future roadway traffic safety interventions in the UAE as well as establishing the priority of such projects among other competing social interests, on the national level. The economic and social impacts of RTAs are shown to be pervasive, affecting the GDP, with all sectors of economic activity affected by the problem. Therefore, the case is made for focusing policy interventions on roadway traffic safety projects in the UAE to save the country's present and future resources. Also, the study makes further recommendations to improve future epidemiological and economic analysis of RTAs in the UAE.

1.5 Thesis Structure

With these aims in mind the thesis is structured in the following order. This first chapter briefly outlines the background of the problem of road traffic accidents globally and within the UAE. Chapter 2 reviews the perspectives and models used in the analysis of the problem of accidents in general and road traffic accidents (RTAs) in particular. Also, the chapter reviews the research on RTAs in developed, developing and the Arabian Gulf countries, including the UAE. The chapter closes by reviewing the models to predict future trends of RTA fatalities and to evaluate prevention strategies, with emphasis on seatbelts.

Chapter 3 reviews methods of economic evaluation and the application of these methods in appraisal of health care and safety projects. First, methods of *Cost Analysis*, *Cost Effectiveness Analysis* and *Cost Utility Analysis* are reviewed, discussed and outlined. Second, the principles underlying the approach of *Cost Benefit Analysis* (CBA) are discussed and examined in detail. Lastly, a conclusion is made.

Chapter 4 reviews some important methodological issues pertaining to the application of the CBA approach in health care evaluations. This includes the use of shadow prices in the estimation of programme costs and benefits and the use of financial tools in discounting the future values of costs and benefits to the present. The chapter closes by explaining the methods for treating the value of human life and methods of treating uncertainty in the analysis.

Chapter 5 reviews the literature attempting to place values on outcomes of RTAs in both developed and developing countries. Firstly, an account of the approaches currently used in RTA economic evaluations is given. This includes describing the CBA based methodological approaches attempting to evaluate human life, in particular: the Human Capital (HC) approach; the Willingness to Pay Value (WTP) approach and the Comprehensive approach. Secondly, a summary review of the empirical studies on the RTA problem is made followed by a conclusion.

Chapter 6 presents the methods and materials used by this study to analyse the magnitude of the problem of RTAs in the UAE. The methods used in describing the trends of morbidity and mortality from RTAs in the UAE are outlined first. This is followed by a description of methods used to forecast mortality from RTAs and to evaluate the effectiveness of seatbelt legislation in the UAE.

Chapter 7 describes the models and methods used for estimating the economic impact of RTAs in the UAE. This includes a description of methods and models used for calculating the unit costs of workplace and home productivity losses, medical treatment and ancillary care services costs, police administration costs, court and legal costs, insurance administration costs, property damages, in addition to the WTP estimates for pain, grief and suffering (PGS) or lost quality of life for individuals following RTAs.

Chapter 8 presents the results of analysis of the secular trends of RTAs, RTA fatalities and injuries and the future forecasts of RTA fatalities in the UAE. The analysis includes comparing the UAE data to equivalent data in some selected developed and developing countries. The results of the evaluation of effectiveness of seatbelt legislation and forecasts of future trends of RTA fatalities are also presented.

Chapter 9 presents the results of the economic evaluation of RTA outcomes in the UAE during 1995. The chapter also presents estimates of the possible savings from the enforcement of seatbelt legislation and the results of the Comprehensive approach.

In chapter 10 the burden of RTAs in monetary terms in the UAE is discussed and contrasted with similar findings from the USA, Sweden, Norway, Kuwait and Jordan.

The final chapter attempts to summarise the results achieved through this research exercise and to relate the findings to the research aims. Also, the policy implications of this study are presented. The shortcomings and limitations of the study and the range of options for the future are also presented in this chapter.

CHAPTER 2

EPIDEMIOLOGY OF ROAD TRAFFIC ACCIDENTS

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The aim of this section is to give a brief conceptual and theoretical background of research on the problem of accidents and injury in general and road traffic accidents (RTAs) in particular. Firstly, an outline of the genesis of the RTA problem is made, followed by a brief account for the models used in the analysis of RTAs. A review of the research experience on RTAs in the developed, developing and the Arabian Gulf countries, including the UAE, follow this. A conclusion is made at the end of each section. Secondly, the models used for forecasting RTA mortality are presented and discussed. Finally, RTA prevention strategies are outlined with specific emphasis on seatbelt legislation.

2.1 The Genesis of the Problem of RTAs

Roadway traffic operation is accomplished by a continuous sequence of decisions by individual road users. This takes place within the determinants of a complex system of roadway engineering, environmental hazards and traffic control of different types of vehicles, small and large, heavy and light. These three determinants bear varying responsibility in accident and injury causation. However, it is evident that a fourth determinant, the road user, bears the major responsibility (Robertson, 1994). As pointed out by Haight (1994) "road users are not restricted to those who are educated or polite, or those who have perfect driving skills, good judgement and are lacking hostility. The population of road users includes individuals who have consumed alcohol or medication, who lack concentration and calm judgement, who are in a desperate hurry, or who are experiencing an unexpected physical or medical difficulty". It is equally important to remember that the quality of the operation of roadway traffic is not based on these personal attributes only. Many other factors, including law and social norms and perceptions influence the behaviour of road users. Therefore, it is fair to conclude that despite the efforts of traffic safety engineers, legislators, health authorities and municipal authorities to regulate and control RTAs, some people at some times disregard traffic lights, evade police surveillance, drive while in an inappropriate physical or mental state, take unreasonable chances, or engage in similar deliberately risky behaviour that leads to RTAs. Beyond that, and perhaps more importantly, as pointed by Bener (1994) "ordinary road users in ordinary circumstances sometimes fail to see or comprehend traffic risks and then fail to react and take appropriate reaction". These road user failures do exist, in spite of any measures, which could reasonably be imagined. The intermingling of these four determinants dictates the necessity to investigate their causal impact in RTAs in order to identify possible prevention measures.

2.2 Concepts and Definitions

The term 'accident' has taken a number of definitions in the literature. Heinrich (1959) defines accidents as the unplanned and uncontrolled event in which the reaction of an object, substance, person or radiation results in personal injury or the probability thereof. Saari (1986), defines 'accidents' as a process of parallel and consecutive events leading to a harmful consequence (Saari, 1986). The WHO defines an accident as an event or sequence of events that results or could result in an injury (WHO, 1989). Avery (1995), recognising the fatalist nature of the WHOs expression, suggested an alternative definition describing an accident as 'a sudden event or sequence of events which, for an individual or groups of individuals, is apparently unpredictable and which may or may not result in injury'. He argues that 'the analysis of accidents shows that many of them are predictable with known risks for certain groups or individuals and in many cases with predictable outcomes' (Avery, 1995).

It appears from the preceding definitions that the term 'accident' is closely related to the term 'injury'. However, the fact is that the two concepts refer to two separate, but mutually interrelated phenomena that take the form of cause and effect, action and reaction or exposure and outcome - in epidemiological terminology (Andersson, 1999). Though, both concepts are interchangeably used in the literature to refer to the problem of accidents and injuries, it is clear, from a public health perspective, that the two phenomena are distinct in etiological nature and as such they need to be addressed and analysed separately, as will be explained shortly. However, some public health circles in North America and in Australia argue that the term *accident* should be abandoned and replaced by the more scientific term *injury (*Langly, 1988; Baker *et al.,* 1992*)*. They advocate that the word accident has a connotation of something unpredictable and unpreventable like an act of God. For that reason, they contend that continuing using the term would 'reinforce people's beliefs in supernatural explanations, which will prevent them from taking counter preventive measures' (Andersson, 1996). They argue that the word *injury* is preferred on the basis that injury is the health outcome to be prevented and as such it is the one that needs to be focused upon (Langly, 1988; Baker et al., 1992). Avery (1995), Bijur (1995), Andersson (1996) and others contested by arguing that the two terms are not interchangeable since they clearly refer to two separate phenomena. Andersson (1996) - clearly recognising the difference - contends that, "they are certainly intimately related in the sense that one lead to the other but that does not mean that one can replace the other". He continues 'the simple fact is that an accident is a sudden or unintentional event that can give rise to injury, but it may lead to other consequences such as disease (e.g. from intoxication or radiation) or material damage only. On the other hand, an injury can be sustained by means of an accident, but also as a result, for example, of violence or suicidal attempt' (Andersson, 1999). Moreover, Bijur (1995), argues that "just as the single word accident did not adequately convey the complexity of the phenomenon, and in fact added a misleading etiological assumption, the word injury alone will represent the outcome of the process only, in which an event, previously referred to as the accident, plays a central part'.

However, it is likely that those arguing for the term 'injury' to replace 'accident', tend to emphasise and focus on the health outcomes of accidents, in terms of injury and death from professional background. While those arguing for the continuity of the term 'accident' tend to emphasise the importance of analysing the underlying causal factors of the event 'accident' in addition to its overall consequences such as injury, material damage and disturbance to economic production; i.e. not necessarily those related to physical injury alone. However, it is clear that abandoning or banishing the word 'accident' from injury research, as noted by numerous researchers, could result in practical difficulties such as blurring the causal background of accidents, thereby hindering causal analysis and also, as noticed by Andersson (1999), excluding the analysis of other health and material effects resulting from accidents, such as cancer from sudden gas or radiation outlets, or infection from contaminated equipment through poisoning (Andersson, 1999). That is in addition to the conceptual problem interchanging the 'event' and the 'outcome'.

Many researchers working in the field recognised the importance of expanding the scope of the roadway safety research beyond its previous focus on either accidents or injuries to a more comprehensive approach addressing both issues as an interrelated phenomenon. In essence, the two viewpoints should compliment each other by combining accident-injury into one theme or concept that provides the theoretical basis of the research effort aiming to control accidents and injuries. This is the approach taken in this study.

2.3 Accident Research Methodologies and Theoretical Frameworks

As pointed out earlier, the increasing impact of RTAs over the last century has led to an increasing concern and focus on the problem, especially in developed countries. This concern was inevitably converted into organised research and government interventions using interdisciplinary approaches. As a result, numerous models and frameworks, mainly from the fields of public health and safety engineering, have been developed and advocated for accident analysis. Those models attempt to explain the basic science of accident causation and prevention from different perspectives. In this section a brief review to the conceptual and theoretical foundations of accident and injury research in general and those relating to RTAs in particular is made and discussed.

The literature on accident and injury causation includes three linear theoretical models and frameworks: the Heinrich's Domino model, the Haddon matrix and the epidemiological models (Andersson, 1999). These three models are designated in the literature as linear because they explain the accident and injury phenomena as a linear process, with a time dimension (Andersson, 1999). The word causation as it is used in these models means that something that comes before in time influences the occurrence of the subsequent outcome variable. The accident is normally perceived as something sudden and unexpected, leading (down stream) to harmful consequences, such as injuries. The genesis of an accident, in turn, could be explained as a flow of causal and mutually interrelated mechanisms (upstream), which can be analysed at various distances in time and at various social and societal levels (Andersson, 1999). Thus, 'time' and 'level' constitute the basic and common background for these linear models in accident and injury research. In the following section a brief account is given for each of these models.

2.3.1 Heinrich Domino Model

The first linear model was "Heinrich's Domino model", first presented in the 1930s (Heinrich, 1959). The model was initially intended for occupational safety purposes, but was found useful for accident-injury analysis. As described by Andersson (1999) it takes the form of five domino bricks in a row, representing: 1) *environment*, which influences upon 2) *human* activities, from which originate 3) *hazards*, which give rise to 4) *accidents*, leading to 5) *injuries* (Andersson *et al.*, 1999). The idea behind the domino analogy is to illustrate causation mechanisms as a liner flow of time-ordered stages or events. In the mean time this mechanism provides the options available for primary and secondary prevention by intervening in the various stages of the flow process. For example, most of primary-roadway traffic-safety intervention strategies could be sought to intervene between environment, human activities and hazards (e.g. seatbelts, airbags, etc.).

However, the model has played and continues to play an important role in efforts attempting to establish the basic science that organises the analysis of accident causation and prevention. It has led to the development of succeeding models, in accident investigation, which are far more elaborate as will shortly be explained.

2.3.2 The Epidemiological Model

The second framework, which has been utilised for explaining the outcomes of accidents and injuries, is the epidemiological model. Epidemiology was initially developed from the perspective of infectious diseases, which is largely reflected in its vocabulary and methods. For that reason the model defines accidents as an *epidemic* disease of non-communicable nature (Farmer and Miller, 1995). Accordingly, accidents are seen as if they have their own natural history, and follow the same epidemiological pattern as any other biological disease – that is the *agent*, the *host* and the *environment* interacting together to produce injury or damage. The same epidemiological indices are used for assessing the magnitude and causes of RTAs as are used for other diseases (e.g. risk factor analysis, proportional mortality rates, injury severity rates, and the assessment of disability, using the International Classification of Impairment) (Andersson, 1999). Thus, accidents were found to occur more frequently in certain age groups, at certain times of the day and the week and at certain localities. Furthermore, some people were found to have higher susceptibility to accidents than others (especially under the influence of alcohol and drugs). Epidemiological based study designs such as case-control designs, cross-sectional analysis, observational studies, time series and trend analysis were the common designs used in describing and analysing the accident-injury problem in most countries in the world.

In summary, the model arose from the theoretical basis of epidemiology and uses the same constructs. Those constructs have helped to identify RTA risk factors and consequences, defining their frequencies and trends and determining what safety measures could be elaborated for preventive purposes in most countries in the world. Examples of preventive strategies include drivers' education, legislation (e.g. seatbelts and safety helmets for cyclists), improvement of roadway engineering, etc. The model is mostly popular among public health scientists and is the dominant approach in accident-injury research.

2.3.3 **The Haddon Matrix Model**

The third model, which apparently was built upon the basis of the Heinrich's Domino and the epidemiological model, is the Haddon matrix (Runyan, 1998; Andersson, 1999). William Haddon applied the principles of public health and epidemiology, and the Heinrich's principles of accident analysis, to the problem of traffic-safety and injury prevention. The major contribution by Haddon was that in spite of the perceived "unpredictiveness" of accidents Haddon decided that 'they should be addressed, analysed and understood by means of scientific approaches used in epidemiology' (Haddon, 1980). He implemented this by introducing the concept of 'agent' to the analysis of the causation process of injury as applied in the Domino model. He defined the *agent* of injury being 'energy' that ignites the accident-injury process, similar to the biological process of infection in epidemiology. For example, heat produces burns, bullets produce wounds and fractures, etc. This stands for Heinrich's first three bricks in the Domino model (the environment, human and hazards). By adding this concept it was possible, for the first time, to maintain consistency in epidemiology between its various fields of application, including injury. As noted by Andersson (1999) 'the concept embodies the dynamic relation between the elements of environment human and hazards that is necessary to produce the *energy* that leads 'down stream' to the effects and outcomes of accidents (injury, death, disability and material damage)' (Andersson, 1999). As such, motor vehicles and stairs are seen as vehicles of energy and the 'energy' in turn is seen as the disease specific "agent" factor leading to injury (Andersson, 1999).

The major contribution of Haddon was his innovation of a matrix of four columns and three rows combining the public health concepts of host-agent-environment with the dimension of time as targets of change with the concepts of primary, secondary and tertiary prevention (Haddon, 1980; Runyan, 1998; Andersson, 1996). More specifically, the factors defined by the columns in the matrix refer to the interacting factors that contribute to the injury process. The host column refers to the person at risk of injury. The agent of injury is energy (e.g. mechanical, thermal, electrical) that is transmitted to the host through the vehicle (inanimate object) or vector (person or other animal). Physical environments include all the characteristics of the setting in which the injury event takes place (for example a roadway, building, and playground or sports arena). Social and political norms in the cultural environment are referred to as the social environment. Examples include norms and traditions about child disciplines or alcohol consumption or policies about licensing drivers or sales of firearms. The phases of prevention are linked with those of the event (pre-accident, accident and post-accident) phases. Later, these phases have been rephrased into pre-event, event and post-event to encompass injuries other than RTAs (Runyan, 1998). The result is a matrix of twelve cells which layout an operational framework for understanding the origins of the injury problem and for identifying multiple countermeasures and prevention strategies to address the problem. The analysis of the alternative strategies that fit each cell of the matrix can generate a list of compelling countermeasures for addressing a variety of injury and public health problems (Runyan, 1998).

Though the model helped in understanding what separates injury from disease, it was found to have its clear limitations. For example, it excludes psychological trauma outcomes from the injury concept (Andersson, 1996). Effects such as depression, apprehension or anxiety from injury and pain from bereavement, anguish and sadness for a loss of a friend or a relative are not considered in the matrix. However, despite these limitations the Haddon's matrix, which has been used for more than two decades, has made an incredible contribution to guiding research and developing roadway traffic interventions to improve traffic safety.

2.3.4 **Surveillance Models**

A major problem in accident and injury research is the quality and the quantity of data. Data on accidents and injuries are traditionally available from two sources: medical sources and the police or event-based circumstantial sources. Because of the difference in the emphasis of each of these sources, due to the differences in the purposes for their collection, researchers working in the field have always been confronted with the inconsistency between the medical (based-event) sources and the circumstantial (pre-event) police sources, and have generally favoured the former. The police sources on accidents traditionally concentrate on the circumstantial and security aspects of RTAs for the sake of verifying the legal liability of the parties involved, with little concern about their health outcomes. On the other hand, the medical sources on RTAs traditionally concentrate on the injury effects and outcomes with little or no concern about their circumstantial (event-based) reasons. With few exceptions, this disparity is seldom resolved in most countries of the world, i.e. by integrating both sources in one single source with the intention of understanding the accident-injury problem.

However, it is axiomatic to maintain that for purposes of preventing accidents it is essential to have access to information on *when*, *where* and *how* accidents take place, and equally important to know the details about the health outcomes of these accidents. These elements together form the basis of the approach of Public Health Surveillance (PHS). PHS is the public health approach of monitoring disease for the purpose of developing control measures. A growing body of evidence exists to suggest that the application of the approach to accident-injury analysis is a key instrument that can provide the basis for an ongoing, active control of RTAs and their consequent outcomes (Laflamme, 1999; Andersson, 1996; Menckel, 1996). The WHO defines the approach as a chain of four interrelated activities, including: 1) the systematic collection of data; 2) the consolidation and analysis of collected data; 3) the dissemination of information by means of narrative epidemiological reports to practitioners of public health and to others who need to know, and; 4) the follow up to see that effective actions have been taken (Laflamme, 1999). Parallel to these outlines, the surveillance approach to accident-injury control and prevention is described by Laflamme to include collection, assessment, development of prevention strategies and evaluation of these strategies (Laflamme, *et al.*, 1999). The application of the approach can be very simple or sophisticated, depending on the goal the system aims to serve. These can range from public health authorities of populations of various sizes such as a local community, to a region, a country or a group of countries (Laflamme, 1999). The goals they can serve include quantifying the health and financial burdens of injury (e.g. quantitative estimates of morbidity and mortality from RTAs) in a given population, monitoring incidence or prevalence of injuries, characterising the populations at risk, identifying possible risk factors and determinants (i.e. detecting clusters of accidents) and thereby stimulating epidemiological research, describing trends and evaluating injury prevention programmes, intervention measures socio-economic trends and safety promotion programmes (Laflamme, 1999).

Various efforts were made, at a national level, in a number of countries to develop PHS systems oriented toward preventing RTA injuries. However, these systems have not yet been successful in resolving the problem. As described by Laflamme (1999) the scope of those systems only encompass 'the tip of the iceberg' of the accident-injury phenomena. As pointed out earlier, the data provided by those systems is mostly insufficient and inconsistent due to the lack of integration between the tow parties handling the problem. Examples, of national reporting systems oriented for RTA surveillance in the world include the Fatal Accident Reporting system (FARS), which counts the fatal motor vehicle crashes from Police and medical sources in the US; the National Accident Sampling system (NASS), which analyses a representative sample of data on US motor vehicle crashes from Police sources; the Canadian Accident Injury Reporting system (CAIRS), which registers all types of accidental injury from hospital sources; the Dutch Home and Leisure Accident Surveillance System (PORS), which documents injuries from accident and emergency sources and; the Victorian Injury Surveillance system (VISS), which registers all injury types at all ages from accident and emergency medical departments in Victoria, Australia. These databases provide important information for research in this field.

However, a pioneering effort to adopt an optimal PHS system was the one attempted in Sweden where a classification system called the Swedish Work Injury Information System (ISA) was introduced in 1978 to address occupational accidents and injuries together (Andersson and Lagerlof, 1983; Linden, 1996). The overall objective of the ISA was to collect, compile and feedback information on occupational injuries to the entire health and safety sectors at all levels. The fundamental idea underlying the meticulous recording of the sequence of events involved in occupational accidents is to enable the identification of the causal mechanisms underlying their occurrence. The model replaced the ICD E-code in Sweden, after blaming the latter for mixing the variables of accident and injury into a one dimensional code - a practice that was found to hide important pre-injury information which is essential for accident prevention (Andersson, 1991). The ISA is a multivariate-detailed model based on an in-depth analysis of typical occupational accidental scenarios. The historical importance of the ISA system is that it inspired the innovation of a generic system addressing all types of accident-injury problems in the Nordic Peninsula. By modelling and standardising the various types of accident-injury events linked to possible extrinsic sources of risk, it was possible to achieve a much more comprehensive and process-like recording system of data in the Nordic Peninsula, with acceptable cross-coding reliability, known under the acronym NOMESCO, which means Nordic Medico Statistic Committee. The committee, which inspired the system, wanted a universal classification for general preventive oriented injury surveillance purposes (Andersson, 1999). The NOMESCO is less classified than ISA but is based on a similar frame of reference (Andersson, 1996).

2.3.5 **Summary**

It is apparent from the review that the scientific models of public health supplemented by surveillance data from Police and medical sources formed the backbone of research efforts on accident causation and injury prevention over the last four decades. It is evident from the literature that the epidemiological based study designs were the common designs used in describing and analysing the accident-injury problem in most countries in the world. This is not to contradict thé fact that other frameworks were also used for analysing the accident-injury problem. The Domino model has clearly contributed to illustrating the causation mechanisms of accidents and consequently in organising their prevention strategies. The Haddon's model, by combining causation analysis and injury prevention, helped to maintain consistency in the analysis of injury and the analysis of the causal factors of accidents. In addition consistency was maintained between epidemiological analysis of injury and its other fields of application.

An essential area, attracting attention nowadays in the analysis of the accident-injury problem is the integration of the traditional data sources of the problem; i.e. the circumstantial (event-based police sources) and the medical and health sources, into one single source that relates causes and outcomes of accidents. Various efforts are underway in many parts in the world to develop integrated surveillance systems for accidents and injuries and pioneering efforts are being made in Sweden and the Nordic Peninsula (NOMESCO).

2.4 The Impact of RTAs in Developed Countries

The RTA problem has long been the focus of research and study in developed countries, and fatality and injury rates there are generally declining (Elvik, 1994; DiGuiseppi, *et al.* 1997; Osberg,1992). In this section a review for a number of recent studies on RTAs in some developed countries will be made. Those studies are mainly based on epidemiological frameworks ranging between observational studies, time series analysis, case-control and cross-sectional analysis.

A recent review of studies on RTA fatalities in 20 industrialised countries revealed that during the 1980s fatality rates of RTAs had been steadily declining (Elvik, 1994). Norway experienced the lowest rate of death from RTAs in 1991, (7.6 per 100,000 population), followed by UK (8.2), Netherlands (8.5), Sweden (8.7), Japan (11.6), Finland (11.8), Australia (12), Switzerland (12.4), USA (16.4), Belgium (18.8), Austria and New Zealand (19), and Spain and Portugal with the highest rates (22.6 and 32.2 respectively). The mean and the median fatality rates per 100,000 inhabitants in these countries declined in 1991 to 15.18 and 13.8 respectively compared to 21.47 and 18.23 in 1981.

A retrospective longitudinal study that investigated the association between economic development and traffic accident mortality in the industrialised world during 1962-1990 (Van Beeck, 2000), calculated traffic accident mortality, traffic mobility (ratio of vehicles to people) and the fatal injury rates in 21 industrialised countries, using mortality and population data from WHO and the International Road Federation (IRF). The study examined cross-sectional and longitudinal associations of those rates with the prosperity level per country, based on data from the Organisation for Economic Cooperation and Development (OECD). The study found a reversal from a positive linear relation between prosperity and traffic accident mortality in the 1960s to a concurrent negative association in the 1980s. At a certain level of prosperity, the growth rate of traffic mobility was found to be decelerating and the fatal injury rate continued to decline at a similar rate compared to earlier phases. In a long-term perspective, the relation between prosperity and traffic accident mortality, was found to be non-linear; i.e. economic development first leads to a growing number of traffic-related deaths, but later becomes protective. Prosperity growth was not only associated with growing numbers of motor vehicles in the population, but also found to stimulate adaptive mechanisms, such as improvements in the traffic infrastructure and trauma care.

A retrospective descriptive analysis of the influence of changing travel patterns on child death rates from injury in England and Wales (DiGuiseppi, *et al.* 1997) revealed that the number of child deaths from injury declined by 34% between 1985 and 1992. Substantial decreases from each of the leading causes of death from injury contributed to this overall decline. Deaths from RTA declined for pedestrians by 24% per mile walked and for cyclists by 20% per mile cycled. This is substantially less than the declines per 100,000 population of 37% and 38% respectively. In contrast, deaths of occupants of motor vehicles (per mile travelled by car) declined by 42% compared with a 21% decline per 100,000 population. In general, car travel became safer for children but the effect on mortality was partially nullified by the increases in the distances travelled by car. The study confirmed the positive effect of safety interventions in reducing deaths and injuries from RTAs and predicted that the associated decline in children's physical activity may lead to future health problems.

A time series analysis was conducted to assess trends of RTA morbidity and mortality in Spain during 1962-1994 (Redondo Calderon, 2000). The study investigated the motorization index (vehicles/population), accident severity index (accidents/vehicles), harmfulness index (victims/accidents) and fatality index (deaths/victims). The Data were obtained from the National Population Census and the Bulletin of the *Direccion General de Trafico* to estimate the above-mentioned indicators for all RTAs in rural and urban zones. Simple and multiple partial correlation coefficients among other variables were calculated. Poisson regression models were also calculated. The study found an increasing trend of RTA mortality and morbidity during the period of observation, especially from 1982 to 1989 in the younger age groups, followed by a decrease since 1990. The aforementioned four parameters were found significantly associated with the mortality rate. The strength of this association was high for the motorization and the harmfulness indexes considering all RTAs. For urban accidents, the fatality index rate is the parameter most strongly associated with mortality rate. The influence of the accident severity index on the mortality rate seemed less important. The study found that the growing exposure rate to traffic accidents observed in Spain (measured by the motorization index) was not directly influenced by public health strategies. The study advised an emphasis on the development of measures focused on controlling the other three indices associated with traffic accident mortality rate, especially those related to harmfulness and fatality.

A study on injury trends of passenger car drivers in frontal crashes in the USA (Martin, 2000) based on sampled crash data, extracted from the National Automotive Sampling System, estimated the annual injury incidence levels during the years 1990-2007. Over that period, the number of crashes was predicted to rise by 71%. However, the number of serious injuries to drivers was expected to rise by only 41% and driver fatalities were anticipated to decrease by 9%. Meantime, the types of injuries suffered by drivers were expected to change. Year-to-year shifts in injury patterns were predicted to result from changes in vehicle size classes within the US vehicle fleet population and increases in seat belt use and air bag availability. The effectiveness of airbags in saving lives was estimated to reach 30%, and with more airbag-equipped cars on the road, the probability of sustaining a life-threatening head or a torso injury was predicted to decline. Since it is established that airbags are not as effective in preventing upper and lower extremity injuries, arm and leg injuries are predicted to become more prevalent in years to come.

A time series retrospective study on cyclist roadway deaths in Greater London during 1985-1992 used coroners' records to investigate the fatal accidents of cyclists recorded on death certificates in London during that period (McCarthy, *et al.,* 1996). The study found a total of 124 cyclist deaths: 68 were injured in London and 56 injured in the "home counties" around London and died in London hospitals. The cyclists' ages were from 8 to 88 years, and 70% were male; the drivers of the other vehicles involved in the cyclist accidents were aged 17-74, and 96% were male. Of the 108 other vehicles involved, 53 were cars and 40 heavy goods vehicles, 5 light goods vehicles, 5 buses and coaches and 5 motorcycles. Fatal accidents occurred with a wide range of manoeuvres, on the part of the other vehicle involved in the accident; of vehicles turning left (driving is on the left in the U.K.), 14 out of 15 were heavy good vessels. Accidents were most often on 2 lane roads and one half were near a road junction. Law violations were recorded in half the accidents; alcohol intoxication contributed only rarely. While injuries to the head were the commonest reported direct cause of death, Inner London deaths were frequently due to multiple injuries. The study confirmed the serious danger to cyclists (particularly women) in Inner London from large and articulated lorries, causing death from multiple injuries.

A retrospective analysis in Finland investigated the trends in age-standardised rates (per 100,000 persons-years) of unintentional injury deaths in adult Finns from 1971-1997 (Kannus, 2000). The study found that in 1971, the leading category of unintentional injury resulting in death among Finnish men was road traffic accidents (age-standardised death rate 47 per 100,000 person-years). This rate declined sharply, reaching 13 per 100,000 person-years in 1997. Simultaneously, the rate of fall-induced death among men gradually increased from 17/100,000 person-years in 1971 to 21/100,000 person-years in 1997. In 1997 the death rate from falling was greater in men than that of any other category of injury. In 1971, RTAs caused fewer deaths in women (rate 17/100,000 person-years) than men, and declined from there to a rate of

6/100,000 person-years in 1997. Concurrently the rate of fall-induced deaths in women also decreased, from 27/100,000 person-years in 1971 to 17/100,000 person-years in 1997. Thus, in the period 1971-1997, falls replaced road traffic accidents as the leading cause of unintentional injury death in Finland.

A retrospective study, on causes of death from injuries in Southeast Scotland was conducted (Wayatt, *et al.*, 1996). Post mortem was performed after all deaths and injury Severity Scores (ISS) were calculated to estimate severity of injuries. There were 331 deaths, at a rate of 20 per 100,000 per year. Of those who died, 49% were less than 40 years old and most were males. 37% of the deaths were caused by road traffic accidents, 16% by falls and 15% by hangings. Two hundred and forty-eight patients (75%) were either found dead upon arrival of Police or an ambulance or died instantly with un-survivable injuries (ISS =75). A further five patients died in the first hour after injury and before reaching hospital. Nineteen (7%) died between 1 and 4 hours after injury. 59 patients (17%) died more than 4 hours after. The results demonstrated that the rate, causes and timing of deaths following injuries in Southeast Scotland differed from the pattern of RTA deaths in other parts of UK.

A cross-sectional retrospective study analysing pedestrian-motor vehicle trauma (PMVT) in Los Angeles in the USA reviewed 273 PMVT victims (16% of all patients with blunt injuries) seen at level 1 trauma centre over a three-year period (Kong, *et al.*, 1996). Patients were analysed by age and grouped as children (age younger than 16 years), adults (age 16 to 59 years), or elderly (age older than 59 years). The results showed that children constituted 27% of the patients, adults 54%, and elderly 19%. This mixture had significantly more children and elderly than the population at large or the entire blunt trauma population at the study area. The majority of patients were males (66%), with females outnumbering males only in the elderly group. Elderly patients were more frequently admitted to the intensive care unit (ICU) and had significantly longer ICU and hospital stays. The injury severity was successively higher in each age group and significantly higher in the elderly group. The case-fatality rate was significantly higher in the elderly patients (13%). Extremity trauma was most common in all three groups, followed by head injuries. The elderly patients were more prone to chest and pelvic injuries, whereas children more often had femoral fractures. Operations were performed in 22% of the patients;

orthopaedic procedures were the most frequent. Most accidents were during night-time hours, especially in the adult group. Half of the accidents occurred during the weekend, with the greatest number on Saturdays. One third of the accidents occurred from October to December. Pedestrian-motor vehicle trauma was found to be a common injury, with distinct epidemiological features that may be useful in accident prevention strategies.

A study analysing trends of RTAs in Greece over 11-year period (1981-1991) revealed that the total number of deaths increased by about 32%, but an important reduction of serious injuries was observed during the same period (Kardara, *et al.*, 1997). The number of fatal injuries increased significantly only in drivers whereas no such increase was observed among passengers and pedestrians. In all three categories of road users, serious injuries decreased significantly with a similar linear regression slope. RTAs in Greece became less severe in all road user groups. RTAs per registered vehicles decreased significantly in all road user and age groups. There was uncertainty about the factors that led to the observed decreases and it was difficult to single out effects of specific measures because of data limitations.

A cross-sectional prospective study was performed in a large population of drivers involved in traffic accidents to determine the significance of drug levels observed in blood, urine, saliva and sweat and which assays are best to perform on each type of sample (Kintz, *et al.*, 2000). Samples of blood (7.5 ml), urine (10-20 ml), saliva and sweat (cosmetic pad spiked with water-isopropanol) were systematically collected in drivers implicated in non-fatal traffic accidents from March to November 1999. The samples were tested for pharmaceuticals (barbiturates, benzodiazepines, anti-depressants, neuroleptics, antiepileptics and antihistamines) and for drugs of abuse by hyphenated chromatographic methods (LC/DAD, GC/MS and LC/MS). Of 198 drivers (bicycle, motorbike, car, truck) tested (age range 13-57 years, 82% males) blood alcohol was found positive in 27 cases (13.7%), ranging from 0.11 to 3.19 g/l (mean 1.49 g/l), exceeding 0.5 g/l in 21 cases. Cannabis was the most frequently observed illicit drug (9.6% of the cases), though its formal pharmacological presence could only be documented by blood testing using GC/MS. Parent compounds were excreted in both saliva and sweat. On-site devices devoted to testing to urine and metabolites were inapplicable. Concentrations in sweat and saliva were very low, particularly for benzodiazepines and cannabis. There was also a risk of external contamination for sweat. The study suggested that saliva might be a good substitute fluid for blood for sample taking on the roadside.

A recent study investigating changes in the rate of fatal traffic accidents for alcohol influenced and non-alcohol influenced drivers between 1983 and 1990 on U.S. roads revealed that decreases in the rates for alcohol influenced drivers exceeded those for non-alcohol influenced drivers (Robertson, 1996). Drivers aged 16-20 had the highest rate of alcohol-fatal-influence in both 1983 and 1990, but they showed the greatest improvement in this rate for all age groups. Female drivers had lower alcohol-influence rates than male drivers in 1983 and 1990, and generally experienced greater decreases in this rate than men. Women aged 25-29 showed less improvement in the alcohol influence rate than women of other ages. These results suggested that efforts to counteract driving while under the influence of alcohol, particularly among teenagers and women, had been effective.

A population-based case-control study was conducted to investigate pedestrian injuries in children, which constitute an important cause of mortality and morbidity (Stevenson, *et al.* 1996). Specific hazards that contribute to these injuries were identified to enable the development of preventive strategies. 40 factors of traffic and road environment, which contribute to the likelihood of childhood pedestrian injury, were examined. The factors of interest were measured at 100 places of injury and 200 control sites between December 1991 and December 1993. The volume of traffic (odds ratio [OR] = 2.16 for an increase of 100 vehicles per hour) in combination with the proportion of vehicles exceeding the speed limit (OR = 1.04 for each 1% increase in average speed) and the absence of footpaths (OR = 11.0) were associated with significant increase in the risk of injury. A graded inverse relationship was present between socio-economic status and the odds of pedestrian injury. These findings have obvious implications for public health, as the features of the physical environment are potentially modifiable.

A study in the US investigating the effectiveness of seat belts on morbidity among paediatric motor vehicle crash victims, injured severely enough to be hospitalised, showed that of the unrestrained children 4.5% died, compared to 2.4% of restrained children (Osberg, et al., 1992). Unrestrained children had a higher proportion of injuries in four of five anatomical regions, were more severely injured, stayed longer in the hospital, and were 15% more likely than belted children to be discharged with impairments.

2.4.1 **Summary**

The literature review demonstrates that public health methods were the dominant approach used by researchers in developed countries to describe and analyse the problem of RTAs. It is important to note that because ethical and legal obstacles precluded the use of randomised controlled trials when analysing traffic risk, the designs of the studies reviewed were observational, measuring association between the variables of the RTA problem. Though such designs do not establish causality, which requires experimentation in randomised controlled designs, these studies succeeded in identifying the trends of the problem, specifying its causal factors and determining the preventive measures that might be effective in alleviating the problem. Some studies used trend analysis and succeeded in quantifying the age, gender and cause specific trends of the problem. They confirmed that the magnitude of the RTA problem was steadily declining in most developed countries. The time trends were particularly essential for drawing comparisons among the roadway traffic safety experiences of the various countries, thereby paving the way for others to benefit from the injury control practices of the different countries.

A number of studies used case-control (or case-referent) designs to investigate the association between exposure to the risk of accidents and subsequent injury, where use is made of information from observational data. Examples are studies on seatbelt and helmet usage among motor-vehicle occupants and cyclists, which attempted to quantify the risk of injury from traffic crashes among users and non-users. The relative risk (the ratio of incidence among the exposed and the unexposed) was estimated using the odds ratio formulae ($R=ad/bc$). The odds ratio was found useful in appraising the various safety devices, measures and practices before advocating them for controlling or preventing the accident-injury problem. It is evident that those efforts helped to improve traffic safety interventions in a number of developed countries as well as contributing to their spread to other developed and developing countries.

Regarding data, some studies used the WHO International Classification of diseases (ICD) system to assess the burden of injury and injury severity from RTAs. Others used the Abbreviated Injury Severity Scores (AIS), the Glasgow Trauma Scores (GTS), and the Injury Severity Scores (ISS) systems as sources to assess and estimate injury severity. One study attempted to use the outcome data of injury, classified on the basis of Diagnostic related Groups (DRG). The majority of studies used data assembled from Police records and cross sectional data. No study is yet available that is based on fully integrated data systems, relating final outcomes of RTA injuries with pre-event, exposure information.

Despite the shortcomings and the difficulties involved in most studies in this area, research efforts have clearly contributed to increasing the public awareness and knowledge about the magnitude of the problem. That effort, however, resulted, sometimes, in minimising the scale of the problem in developed countries as shown by the persistent decline in the trends of the problem there.

2.5 The Impact of RTAs in Developing Countries

In contrast to the experience in developed countries, the RTA problem has received little attention in most of the developing or underdeveloped countries. In many of these countries the traffic safety situation is worsening (Jacobs, 1982; Jadaan, 1983;; Mekky, 1985; Tawfiq, *et al.,* 1985; Nafal *et al.,* 1996).

Although South Korea has reached outstanding economic standards in the past decade, the trend of fatality and morbidity due to RTA there contrasts with the improvements in the aforementioned developed countries (Lee, 1995). In 1993 the RTA fatality rate per 10,000 inhabitants was 2.3, the fatality rate per 10,000 vehicles was 13.6, and the injury rate per 10,000 vehicles was 460 and the overall trends for RTA injuries and fatalities were found to be increasing during the 1980s.

Morbidity and mortality from RTA in the Bangkok metropolis were high with the trend increasing over time, thus establishing one of the major public health problems in the Kingdom of Thailand (Bohning, *et al.*, 1997).

In Thailand, a study (Sintuvanich, 1997) found RTAs during the 1980s became a leading cause of death. The study identified the relationship between industrialisation and the trend of fatalities from road traffic accidents using regression analysis. Observing per capita income and national industrial production, it is apparent that 1986 marked the beginning of the period of industrialisation. Since that year, the mortality rate from road traffic accidents has increased rapidly. This trend has been more marked among males, people between 15-35 years old and in the central region of the country. This trend was a warning to search for measures to prevent this harmful side effect of industrialisation.

In Jordan a study (Jadaan, 1983) found the RTA incidence increasing between 1980 and 1983. The magnitude of the problem over the study period showed almost a steady increase (6% average annual) in the number of accidents and resulting casualties. Both increased over 40% during the study period. Over three-quarters of the accidents were in urban areas and during daytime; pedestrians constituted over 40% of all injuries; and 73% of total injuries involved people less than 30 years. A further analysis during 1986 revealed that RTA rates were significantly higher during the summer months and on Saturdays. The gender distribution revealed that 96% of drivers involved in accidents were males and about 95% were Jordanians. Excessive speed was the most important cause of accidents.

In tropical Africa, RTA trauma is only beginning to assume importance as infections and malnutrition are controlled. In a retrospective analysis, reviewing the epidemiology, management, and unnecessary laparotomies for paediatric blunt abdominal trauma (BAT) in Nigeria, a sample of 57 children, aged 15 years or less at the Ahmadu Bello University Teaching Hospital, Zaria – Nigeria, over 12 years, was selected (Ameh, *et al.,* 2000). The average age was 9 years and the male-female ratio was 3.8:1.0 Seventy-four percent (74%) of abdominal injuries in children were found to be due to blunt trauma. The commonest causes of injury were RTAs (57%), 88% in pedestrians and 59% in children aged 5-9 years. BAT in this population resulted predominantly from RTA in pedestrians.

A descriptive analysis of RTAs and injury data in Kenya (Odero, 1995) revealed that the numbers killed due to RTAs increased by 578% and non-fatal casualties rose by 506% between 1962 and 1992. The RTA fatality rate per 10,000 vehicles increased from 50.7 to 64.2 and the fatality rate per 100,000 population rose from 7.3 to 8.6. 60% of the RTAs occurred on rural roads and had a higher case fatality rate (CFR) (16%) compared to those in urban areas (11%). Human factors were responsible for 85% of all RTAs. Vehicle-pedestrian collisions were most severe and had the highest CFR (24%) while only 12% of injuries resulting from vehicle to vehicle accidents were fatal. Of all RTAs reported, pedestrians comprised 42%, passengers 38%, drivers 12% and motorcyclists 8%.

In Turkey, RTAs cause substantial injuries and deaths. A retrospective study surveying new patients with traumatic spinal cord injuries in all hospitals of Istanbul revealed that the estimated annual incidence was 21 per million population (Karamehmetoglu, *et al.*, 1995). Of all patients 72% were under the age of forty. RTAs caused 43% followed by falls (41%), gunshot injury (5%), and stab injury (2%).

A prospective observational study was carried out at the Emergency Department, Hospital Kuala Lumpur in Malaysia to determine the proportion of accidental head injury among children and the circumstances of injury (Rohana, 1998). The study was carried out on all children below 14 years who presented to the Emergency Department with accidental head injury. Accidental head injury made up (4.75%) of all cases seen at the Casualty Department. The ratio of boys to girls was 2:1. The mean age of head injured children was 5.2 (S.D. 3.63) years. The leading cause of head injury was fall (63%) followed by road traffic accidents (RTA) in 30.7% while the rest were due to 'impact' (injury caused by flying object or missiles) injuries. More than half (54.4%) of those injured in RTA were pedestrians. Pedestrian injury was particularly important in the 5-13 years age group, where adult supervision was lacking in two thirds of the children. None of the patients who were involved in vehicle-related injuries had used a suitable protective or restraining device. All three patients who died were from this group. The study emphasised the need for stricter enforcement of laws related to the use of protective devices and measures to decrease child pedestrian injury. The study also recommended that issues of lack of adult supervision, both in and outside the home, should be addressed.

A case control study was conducted in 1996 among primary school student in Terengganu in Malaysia to assess the risk of road traffic accidents (RTAs) among primary school children in Kuala Terengganu (Fatimah, 1997). The objective of the study was to determine the relationship between RTAs and factors such as socio-economic status, distance from school, number of siblings, behavioural problems, knowledge and attitudes of pupils and their parents towards road safety and parents' educational status. A total of 140 cases were obtained from 3 urban schools and 3 rural schools. Cases were matched with control according to age sex and locality of residence. The study found significant protective associations between RTAs and pupils' knowledge regarding road crossing (OR =0.40, 95% CI = 0.19-0.85), parental supervision (OR = 0.43, 95% CI = 0.19, 0.64) and parents having driving licences (OR = 0.99, 95% CI = 0.856-0.999). The study recommended that road safety education for pupils and parental supervision are key measures in preventing road traffic accident among primary school children.

A study on the impact of motor vehicle injury in Taiwan, using potential years of life lost (PYLL), showed that RTAs were a major harmful side effect of industrialisation (McKinney, 1994). In 1992 Taiwan had a higher PYLL per 100,000 population due to RTAs (350/100,000) than cardiac disease, cancer or strokes. In contrast, 25 years earlier more PYLL was due to cancer, strokes, cardiac disease and tuberculosis than RTAs (106/100,000). Taiwan's PYLL rate was much higher than three other industrialising countries (Chile, Korea and Hungary) and twice that of the US. Explanations given for the dramatic rise in RTA deaths in Taiwan were the high rate of use of motorcycles, lack of motorcycle helmets, increase in alcohol use, high motor vehicle density and road and safety design problems.

2.5.1 **Summary**

Similar to the experience in developed countries, most research addressing the problem in developing countries is based on epidemiological models. Despite many shortcomings, concerning data availability, the studies made so far succeeded in directing attention to the size of the problem in developing countries. They confirmed that RTAs constituted a major and growing public health problem in many developing countries, in terms of both morbidity and mortality, not to mention property damage, disability and the other known harmful physical and emotional consequences.

The data sources for the problem in developing countries were mainly Police sources, which suffer from underreporting, incompleteness, and inconsistency as noted by many researchers working in this field. As a consequence, research efforts investigating the problem are denied the type of data available to developed countries. That could explain why in many of these countries the RTA problem is not yet appropriately considered, as a public health problem, which requires attention equal to other causes of death and illness such as infections and cardio-vascular diseases (CVD). It is likely that the figures reported reflect 'the tip of iceberg' of the true size and impact of the problem due to the shortage of information.

2.6 **The Impact of RTAs in the Rich Arabian Gulf Countries**

In the Arabian Gulf region, which comprises the UAE, Saudi Arabia, Oman, Qatar, Bahrain, and Kuwait, some research on the RTA problem has been conducted in the past few years (Bener, *et al.,* 1985, 1992, Al-Qabisi, *et al.*, 1989). Compared with many developed countries, Gulf countries have higher rates of morbidity and mortality from RTAs (Bener, *et al.,* 1985, 1992, Al-Qabisi, 1989).

A study (Mekky, 1985) investigating RTA injuries by pedestrians in three, rich and rapidly growing Gulf countries, namely Saudi Arabia, Kuwait and the UAE, revealed that pedestrians fatality rates per 100,000 population were found to be significantly higher compared to those of developed countries. Pedestrian accident rates were found increasing and their injury severity was worsening, with a substantial proportion resulting in fatality. Young pedestrians were particularly at risk, constituting about 40% of total pedestrian fatalities. The study suggested that relative to other developing countries, the Gulf countries had a reasonably good record of pedestrian accidents although it was poor when compared with developed countries.

A recent study on causes and effects of RTAs in Saudi Arabia (Ansari, *et al.*, 2000) found that between 1971 and 1997; 564,762 people died or were injured in RTAs; a figure equivalent to 3.5% of the total population. Of these 66,914 people died on Saudi Arabia roads due to accidents, amounting to one person killed and four injured every hour. Over 65% of accidents occurred because of vehicles travelling at excessive speed and/or drivers disobeying traffic signals. Of deaths in Ministry of Health hospitals, 81% were due to RTAs and RTA victims occupied 20% of hospital beds. Also, 79.2% of patients admitted to Riyadh Armed Forces Hospital with spinal injuries sustained their injuries as a result of RTAs. The study recommended compulsory use of safety seat belts in vehicles and the setting up of a new database to collect, store and analyse information relating to RTAs.

In a study of fatalities in Jeddah, Saudi Arabia in 1992, RTAs were found a major cause of death (Jadaan, 1988). The percentage of RTAs involving pedestrians increased from 33.7% in 1974 to 43.8% in 1985. The age distribution of pedestrian accident victims showed that children aged less than 16 years constituted more than 60.5% of pedestrian fatalities, 52% of pedestrian injuries and 55% of "all" pedestrian accidents. About 15% of pedestrian fatalities were people of more than 60 years of age and less than 25% of pedestrian fatalities were 16 to 50 years of age.

Another study on the epidemiology of road fatalities in Kuwait (Bener, *et al.*, 1992) found that road traffic fatalities there arose from the fourth leading cause of death in 1977 to the third in 1987. The crude RTA mortality rate, per 100,000 population in 1987 was 14.6; the lowest in the Arabian Gulf region. The mortality rate among the age group 60 and above was found to be higher while it was relatively low among the age group 0-14. The rate of potential years of life lost (PYLL) was 6.0 per 1000 population. However, compared to other countries in the Gulf region, injury and fatality rates due to RTA in Kuwait were relatively low.

A study in Saudi Arabia (Nafal, *et al.*, 1996) revealed that RTAs form a major health hazard particularly during Ramadan (the holy month of fasting for Muslims). RTA trauma was found to be increasing in direct proportion to the increase in the number of vehicles. An audit of RTAs over a one-year period revealed that, out of 361 victims, 16% were under 10 years and 47% between 11 and 30 years. None of these involved in accidents were wearing a seat belt. Half of the children injured were pedestrians. There was a male to female ratio of 4:1 reflecting the driving laws in Saudi Arabia (females driving is prohibited). Burst tyres due to intense heat were identified as a common cause (39%) of accidents.

2.6.1 **Summary**

Compared to the experience of developed countries, the RTA problem seems to be far more serious in the Gulf Arabian countries where the secular trend of road traffic accidents, and the morbidity and mortality associated with them are relatively high. With few exceptions, the injury and fatality rates were higher, compared with both developed and other developing countries. The severity of injuries was also believed to be higher. The younger age groups, especially those below 40 years, and most particularly the paediatric age groups, were at higher risk of injury and death.

However, official attention to the consequences of the problem is growing in some of these countries. Kuwait is an example.

2.7 **The Impact of RTAs in the UAE**

The problem of RTA received increasing attention in the UAE in recent years (Weddell, *et al.,* 1981; Bener, *et al.,* 1992, 1996, 1998). Among these studies was a preliminary study on mortality and morbidity associated with RTAs during the period 1983 to 1992 (Bener, 1996). The study revealed that the mortality rate per 100,000 population declined from 42.6 in 1984 to 38.28 in 1992. Compared to other countries in the region, the UAE has relatively better RTA rates, ranking second behind Kuwait. However, compared with the major industrialised countries, UAE has higher rates of morbidity and mortality due to RTAs.

A retrospective descriptive study in Al-Ain hospital in the UAE (Bener, et al., 1998) on injury mortality and morbidity among children in the UAE during 1995 revealed that most deaths (28.6%) occurred in the 1-4 year age group. Head and neck injury was the major type of injury causing death (57%). The most common cause of accidental death was RTAs (boys 67.1%, girls 60.4%), followed by drowning and burns (8%). In the age group 1-5 years the most common causes of trauma were falls (41.1%), blunt trauma (38.7%) and burns or scalds (64%), while in 5-9 and 10-14 years olds, the most common causes were RTAs; 40% and 32.8% respectively. The majority of boys and girls presented with injuries were nationals.

A prospective study on hospitalised drivers following a traffic accident carried out in the accident and emergency departments of the two major hospitals of Al-Ain city between Dec. 1991 and Oct. 1992 to assess the knowledge, attitude and practice among drivers regarding the use of seat belts, found that the rate of constant seat belt use was 10.5% and frequent use was 4.8% (Bener, *et al.,* 1994). Overall seat belt usage was 15.39%. The study revealed that despite legislation mandating the use of seatbelt, the rate of use of seatbelt in the UAE was very low, much lower than in other developing countries and developed countries, lower even than those which have no enforced seat belt legislation.

An earlier prospective study of traffic injuries admitted to a city hospital in the UAE during a 1 year period revealed that most victims were males under the age of 35 years (Bener, *et al.,* 1996). Most of the accidents and injuries happened during the peak hours 8.00 a.m. and 2.00 p.m. Head injuries were found the most frequent injuries.

A study (Bener, *et al.,* 1994) on risk taking behaviour and RTAs in the UAE during 1990 reported the following frequencies of causal factors: 48.6% due to careless driving and lack of attention; 14.4% due to excessive speed, 2.6% due to drugs and alcohol and 1.9% due to motor vehicle condition, climate and dust. The RTA rates per 100,000 population, per 100,000 registered vehicles and per 100 million kilometres travelled were 21.4, 2.1 and 5.3 respectively; all were higher than the corresponding rates in developed countries.

2.7.1 Summary

In the UAE, RTAs are a public health epidemic, being the second leading cause of death. The literature reviewed, relating to the problem in the UAE and the Gulf, has shown that the crude rates of RTA fatalities and injuries were much higher in those countries than in most developed countries but lower when compared with many developing countries. Among the Gulf countries, UAE has relatively good rates. Also, the overall trend of RTA fatalities and injuries in the UAE has been declining in recent years, although the trend of pedestrian deaths and injuries, especially among the paediatric age group, is increasing. Despite the scale of road-traffic injury severity in the UAE and the other neighbouring Gulf countries little has been done to control the problem. Likewise, there has been no research evaluating the economic costs of RTAs in the UAE, or assessing its implications for the resources available for health care.

2.8 Forecasting of RTA Fatalities

2.8.1 Background

Forecasting of RTA consequences is essential, from a public health viewpoint, to layout the future prospects of the problem if nothing is being done to control it. In the meantime, it is essential for policy making and future planning of roadway traffic safety policies aiming to control RTAs. From an economic perspective, the approach is equally important to demonstrate the cost-benefit ratios of roadway traffic safety projects *vis-à-vis* other competing public interests. Evidence exists to suggest that advocacy for safety projects on the basis of safety arguments alone, will not succeed unless supported with cost predictions of the 'no action alternative'. Projects such as those involving an alteration of roadway engineering (e.g. changing an existing road, roundabout or intersection) are apparently expensive, might lead to inconvenience and enormous losses such as the time lost by road users due to temporary diversions. Even less expensive projects such as the enforcement of safety seatbelt legislation, education or training on safe driving, are labour intensive and time consuming. They can only pass the cost-effectiveness test against other competing projects if their future human and material benefits are adequately demonstrated.

Thus, the rationale for forecasting RTA fatalities is to illustrate to policy makers the implications of the problem if no action is taken to control it and to depict the savings, in resources and human lives, that could be achieved from reducing RTAs. The approach can assist public health authorities to advance ambitious traffic safety projects that might otherwise fail to be recognised.

2.8.2 **RTA Forecasting Models and Frameworks**

Regression models, which are commonly used to identify associations between variables, have been found useful for predicting RTA fatalities. Since the 1940s many attempts have been made in various countries to estimate the future rates of RTA fatalities using regression models. Although, the attempts have been criticised by many researchers for being inaccurate (Garbacz, 1988; Bener, 1990; Jadaan, 1991) they paved the way for other researchers to advance models that better fit the data.

Most studies have been based on the hypothesis that some relation exists between fatality rates, populations and vehicle ownership. Using data on RTAs from different countries, Smeed (1949, 1974) found that the rates of fatalities in RTAs are inversely related to vehicles per capita and that the coefficient is reasonably stable over time and for numerous countries. Using the factors of population (P), the number of vehicles (V) and the number of fatalities (F) Smeed showed that the regression formula (Smeed, 1949):

$$F = 0.0003\ (VP^2)^{0.333} \qquad (1)$$

and, then later the equation (1974):

$$F/V = 0.0003\ (V/P)^{-0.66} \qquad (2)$$

could be used to predict the number of traffic fatalities in any country. In his initial work the first formula gave a good fit for data from 20 countries (Smeed, 1949). It proved to fit fairly well with data for later periods as well (Smeed, 1968; Garbacz, 1988; Bener, 1990). In view of that, many researchers advocated that, given that stability, it is possible to use the model, sometimes with alterations to suit the particular setting (Garbacz, 1988), to predict RTA fatalities in relation to growth in population and motor vehicles with some degree of accuracy. The second formula was also reported to fit well time series and cross-sectional data from many developed and developing countries (Mekky, 1985; Jadaan, 1991).

However, some criticisms exists concerning the precision of Smeed's formula. Preston (1981), using cross-sectional data for 32 countries in 1977 showed that, on average, the expected deaths, as estimated by Smeed's formula, exceeded the observed by 21 percent. When applied to time series data over 20 years for the New South Wales (Australia) Hampson (1982) found that deaths predicted using Smeed's formula were on average 20 percent lower than observed. Andreassen (1985) investigated the relationship between deaths, vehicles and populations for a number of countries over a period of years and concluded that Smeed's formula does not apply universally to all countries.

Those studies argue that Smeed's model is not comprehensive in the sense that it doesn't capture well the diversified elements that are believed to influence RTAs and RTA consequences. They contend that, the variation between countries cannot be accounted for by the use of the coefficients of population and vehicles only. Other elements such as alcohol use, youth, speed, income, accident's cost, secular trends, social and cultural factors may also be useful determinants (Peltzman, 1975; Andreassen, 1985; Preston, 1981). Another problem pointed out is the variation in the availability and validity of data among countries in the world (Bener, 1990, Jadaan, 1991). We have already pointed out in section (2.4.1) that the lack of integrated data systems for the accident-injury problem in most developed countries is believed to affect the validity of studies. In developing countries, the situation is even worse, as no data registration on accidents and injuries of any level of validity is available. Thus, the accuracy and the precision of data on RTAs could vary considerably from one country to another, which could affect the generaliseability of the model across different countries.

However, despite those criticisms, researchers in various countries continue to use the Smeed's formula. Some others built upon it and incorporated other relevant variables to produce models that claim to be far universal and comprehensive. Minter

(1987) developed a model to predict future traffic deaths based on data from UK. His model incorporated the rate of growth of vehicle population, the change in annual distances per vehicle and the expected growth of the population. He produced the following model:

$$\text{Million km per death} = 2.27 + 119.832[1 - \mathit{exp}\,(-x/1400.5)] \qquad (3)$$

It is obvious that the model is not suitable to apply in most developing countries, such as the UAE, due to lack of data on the number of kilometres driven annually by the stock of vehicles and motorcyclists.

Jadaan (1982) used time series data from Kuwait to check the validity of Smeed's formula for data in developing countries. He produced the following two equations: the first to predict RTA fatalities per registered vehicles and the second to forecast fatalities per population,

$$F/V = 0.0004079\ (V/P)^{-0.746} \qquad (4)$$

$$F/P = 0.0004079\ (V/P)^{0.254} \qquad (5)$$

where F, P and V are as defined earlier.

Another analysis carried by Jadaan (1988) using data from the Arabian Gulf countries and methods similar to those used by Smeed produced the following linear regression model:

$$Y = 0.00052\ (X)^{-0.6} \qquad (6)$$

Where,

y = number of fatalities per vehicle

x = number of vehicles per person

The model was better at fitting the data from those countries than Smeed's model.

In Saudi Arabia Bener (1990) produced the following equation, which fitted Saudi Arabia's data and gave estimations within 10 percent error of the actual figures.

$$D/P = 0.000464\ (N/P)^{0.30311} \qquad (7)$$

2.8.3 Summary

It is clear from the studies reviewed that it is not feasible to attempt applying forecasting equations, developed from data for certain countries, to a different country without first checking the fitness of the model to the data under question. This is largely because the factors contributing to RTA fatalities differ from one country to another. Although it is evident from studies using Smeed's equation that the variables of population and registered motor vehicles can highly explain the future trends of RTA fatalities and injuries, it has also been proved that other variables such as disposable income, gasoline consumption, standard of roadway infrastructure, speed limits and drivers' age have a notable influence as well. An appropriate model should, therefore, attempt to address these other factors as well.

2.9 RTA Measures of Prevention and Control

2.9.1 Introduction

Accident and injury prevention programmes are growing in size and depth and involve an increasing number of agencies in most countries in the world. The dramatic increase in the number of motor vehicles, the consequent increases in the numbers and severity of RTA injuries after World War II and the realisation by health care planners of the increasing cost of medical care and rehabilitation of the victims of those injuries, led to the understanding that more money should be spent on prevention of RTA injuries. This understanding paved the way for a more systematic approach to RTA injury prevention. In particular, traumatologists combined efforts with biomechanics experts to target injury prevention rather than accident prevention. That effort culminated in establishing the effectiveness of safety seatbelts, crash helmets and collapsible steering columns before the 1970s (NOMESCO, 1997). In the following section a review will be made to the research evaluating a common RTA injury preventive measure, i.e. wearing of safety seatbelts.

2.9.2 Safety Seatbelts

The main purpose of safety seatbelts rests in the reduction of injury risk exposure during motor vehicle crashes. Based on the principles of Haddon (1982), classifying safety interventions into active, passive and behavioural or environmental forms, safety seatbelts could be regarded as an active form of safety intervention where the individual consciously elects to utilise the device or not.

It is well established that safety seatbelts are very effective in reducing morbidity (the occurrence of an injury) and mortality in road traffic accidents. Effectiveness is measured as the percentage reduction in injuries and deaths for people with the device compared to people without the device. It is also established that the use of safety seatbelts and other restraints reduce the cost of medical treatment of injuries. A quasi case-control study by Kaplan and Cowley (1991) in the US, evaluating 55 randomly selected belted and unbelted RTA casualties, revealed that seatbelts reduced the total number of injuries by 34%, major injuries by 57%, minor injuries by 20% and deaths to zero in the belted group. The unbelted group had a mean abbreviated injury severity score (AIS) two times as great as the belted group and were hospitalised 1.6 times longer and at double the cost. Some major injuries were prevented by seatbelts, although, among the belted group severe injuries occurred to the head, neck and abdominal regions. The study recommended that both airbags and safety seatbelts should be required for all drivers if the trauma occurring daily on the highways is to be reduced and the acute hospital cost minimised. Another study (Evans, 1986) established that the use of seatbelts among front seat occupants reduced RTA fatalities by 43 (±3%). A study by Viano (1995) estimated the effectiveness of safety seatbelt to reach 42% in preventing fatalities. The study confirmed that the addition of the airbag might provide additional 12% increase in effectiveness (Viano, 1999). Nash (1989) evaluating fatality rates in Toyota Cressidas showed that the fatality reducing effectiveness for Toyota automatic seatbelts was 40%, which was consistent with earlier estimates. A recent study evaluating death and injury to specific body regions by use of automatic shoulder and lap belt systems or automatic shoulder without lap belts, revealed that automatic shoulder belts are associated with a decrease in the risk of death compared to no restraints, although the results were statistically insignificant (Rivara, *et al.*, 2000). Moreover, the study revealed that the use of shoulder without lap belts was associated with increased risk of serious chest and abdominal injury.

The effectiveness of safety seatbelt in reducing the costs of medical care and rehabilitation of injured victims is also well established. An evaluation by Marine *et al.* (1994) for efficacy and cost effectiveness of seatbelt use revealed that 65% of the belted group had no medical costs in contrast to only 29% of the unbelted group. Moreover, the unbelted group accounted for 76% of the medical costs and 72% of the hospitalisations. Miller *et al.* (1998), estimated the costs of unrestrained occupants to account for 42% of the crash cost (Miller, *et al.,* 1998). According to that study, if these unrestrained occupants were buckled up the medical cost crashes would decline by an estimated 18% (almost $4 billion annually) and the comprehensive costs by 24% (Miller, *et al.*, 1998). Nelson *et al.* (1993) evaluated the direct and indirect savings from enactment of seatbelt legislation in the state of Iowa in the US to reach $69.5 million. A study by Congress in the US (CODES, 1996) showed that the average inpatient cost for unbelted motor vehicle drivers admitted to an inpatient facility as result of RTA was more than 55 percent greater than the average cost for those that were belted ($13,937 and $9,004) respectively.

These proportions and estimated amounts suggest the magnitude of savings that can be made by persuading the population to wear safety seatbelts when driving. Moreover, they emphasize the importance of systematic interdisciplinary research, combined with engineering, education and enforcement in curbing the harmful injury manifestations of RTAs, the most costly element of the RTA problem.

2.10 **Conclusion**

RTA morbidity and mortality are thus one of the major public health problems in developing as well as developed countries. The results, shown in the literature reviewed in this chapter, confirmed that mortality and morbidity rates due to RTA are increasing, on average, in most developing countries, while significantly decreasing in developed countries. Similar to the experience in developed countries, the numbers of deaths and injuries among the younger age groups (below 40 years) constitute more than half of the total number of RTA casualties in developing countries. The RTA injuries and fatalities among paediatric age groups, especially the age groups below 1 year and 1-5 years, in both developed and developing countries, are significantly higher than in other age groups and require further investigation. RTA trauma to pedestrians is a common injury, with distinct features, and constitutes an increasing proportion of total RTA casualties, especially in the developing rich countries such as UAE.

CHAPTER 3

FRAMEWORKS OF ECONOMIC EVALUATIONS IN HEALTH CARE AND SAFETY PROJECTS

CHAPTER (3)

FRAMEWORKS OF ECONOMIC EVALUATIONS IN HEALTH CARE AND SAFETY

3.1 Introduction

A fundamental point to make at the outset is that, whether explicitly stated or not, the implicit aim of all economic evaluations is to maximise social welfare. In the words of Drummond *et al.* (1998) "two features characterise economic evaluation, regardless of the activities to which it is applied. First, it deals with the process of ascertaining the relationship between inputs and outputs, or *costs and benefits,* in a way that is useful for decision-making. Second, economic evaluation is concerned with choices.*"* (Drummond *et al.*, 1998).

Indeed, it is only through the careful analysis of the relationship between costs and outputs or costs and benefits that thoughtful decisions can ever be made. This principle applies to evaluations in all areas of human activity, i.e. for private as well as public decision-making (Zerbe and Dively, 1994). On the other hand, the scarcity of resources and the traditional constraints of budgetary expenditure imply that choice has to be made in all areas of human activities. Economists contend that those choices are routinely made on the basis of many criteria, sometimes explicit, i.e. applying methodological analysis, but most of the time implicit, i.e. applying experience and common sense (Drummond *et al.*, 1998).

These two characteristics led economists to define economic evaluation as "the comparative analysis of alternative courses of action in terms of both their costs and consequences" (Drummond *et al.* 1998). Zerbe and Dively define economic evaluation as "a set of procedures for defining and comparing benefits and costs" (Zerbe and Dively, 1994). Therefore, economic evaluation can be viewed as an approach to deciding between different priorities of scarce and limited resources. Accordingly, the tasks of an economic evaluation as elaborated by Drummond (1998) are to identify, measure and value the direct and indirect, tangible and intangible costs and benefits of all possible alternatives under consideration. This typically involves, in the health and safety fields, selecting two or more alternative programmes for appraisal, assessing the costs and consequences of those programmes and to make comparison based on the relative costs and benefits of the programmes. An additional task in completing the evaluation is to discount to the present, the future costs and benefits of those alternatives and to compare their final results. The programmes or projects that yield the highest incremental benefit (the difference between discounted benefits and costs) are usually considered superior and are customarily favoured (Drummond, *et al.*, 1998). Economists consider the results of analysis based on such criteria as full economic evaluations or Cost Benefit Analysis (CBA) evaluations. The approaches fulfilling the criterion include *Cost-Effectiveness Analysis* approach, *Cost-Utility Analysis* approach and *Cost Benefit Analysis* approach. All these approaches treat the cost items in a similar manner but they differ in the extent to which they measure and value consequences and benefits (Drummond *et al.*, 1998).

However, there are other methods of economic evaluation that do not fulfil the criteria fully, and for that reason they are designated in the literature as partial economic evaluations. It is now established that the studies concentrating on the evaluation of costs alone all fall within the category of partial analysis (e.g. *Cost Analysis* and *Cost Minimisation Analysis*). However, Drummond recommends that although the description of 'partial evaluation' is obviously downgrading, it should be noted that this does not imply that such studies are unimportant; "for they represent an intermediate stage in the process of understanding the costs and benefits of the programme or activity under question" (Drummond, *et al.*, 1998).

To comprehend the research attempting to estimate the economic impact of consequences of accidents in general and RTAs in particular we intend, in this chapter, to give an account of the methods of economic evaluation and the application of these methods in health care and safety evaluations. Thus, the methods of *Cost Analysis*, *Cost Effectiveness Analysis* and *Cost Utility Analysis* will be discussed and outlined first. Second, the principles underlying the approach of *Cost Benefit Analysis* will be discussed and outlined in details. Lastly, a conclusion will be made.

3.2 The Methodology of Cost Analysis

Cost Analysis is the simplest form of economic evaluations. Economists reckon that it is essential when the choice between health or safety programmes is dependent on relative costs rather than relative benefits or consequences (Drummond, *et al.*, 1998). The hypothesis implied by the methodology is that the benefits and consequences of the alternative programmes under question are identical and that the evaluation process is essentially a search for the least cost alternative (Drummond *et al.*, 1998). According to numerous economists the costing approach involves four major steps: identification of the main cost categories of the safety or health programme, measuring the quantities of resources that will be used up by the programme (in appropriate standardised units), assigning unit costs or (values) on these resources and summing the results, and, finally subjecting the results to sensitivity analysis and discounting where appropriate (Drummond, *et al.*, 1998; Dively and Zerbe, 1994; Waters, 1997).

Three methods were substantiated to approach these targets, which will shortly be presented. Before that, however, it is important to emphasise that the cost categories identified for analysis, the particular range of costs considered and the viewpoint of the analysis are known to exert crucial influence on the final results of evaluation. According to Drummond (1998) costs comprise three major categories: resource use within the health sector, resource use by patients and families and resource use in other sectors (Drummond, *et al.*, 1998). The emphasis given to any of these categories depends on the viewpoint and the purpose of the analysis. For example, an element that might be considered as a cost from one viewpoint may not be regarded as a cost from another viewpoint. According to Drummond (1998) possible viewpoints include society, Ministry of Health, patient or the agency commissioning the programme (Drummond, *et al.*, 1998). However, the societal viewpoint is considered the broadest one and most economists recommend it. However, it may be equally important to investigate other key viewpoints including individual institutions and patients. A complementary problem in this regard is the identification of the particular range of costs relevant to the programme under consideration, which remains very context specific (Drummond *et al.*, 1998). Anther problem involved in costing is that some allowance need to be made for differential timing of costs and consequences (Drummond, *et al.*, 1998). For example, the future productivity losses of RTA victims and medical and rehabilitation costs that must be incurred in the future cannot directly be compared to costs in the year of the accident. Therefore, future costs should be discounted to the present in order to reflect their present equivalent to society. Thus, it is essential to determine the discount rates that should be used in the analysis and the method to incorporate inflation and uncertainty in these rates as well.

As pointed out earlier three methods exist to costing, namely: the Accounting Costing, the Engineering Costing and the Statistical Costing (Waters, 1997). The accounting costing approach, as the name implies, is based, in its calculations, on the formal information available from routine accounting records of firms and institutions. The approach simply compiles the cost categories relevant to the programme under question and uses that information to estimate or predict the costs associated with a change induced by an input or a programme (Waters, 1997). However, there are three potential difficulties with the approach including: first, recorded books of accounts may not be an accurate guide to the actual opportunity costs of assets (taking in mind that opportunity costs are the relevant cost for decision making); second, the cost accounts may not distinguish between current (or operating) costs and those which remain fixed in the short run (e.g. laboratory equipment and hospital theatres); third, the accounting process itself may obscure between costs and specific service outcomes (Drummond, *et al.*, 1998). That is to say that the aggregation of accounts may prevent identifying what proportion of costs can be identified with a particular service. That could lead, as elaborated by Waters (1997), to failure to reveal accurately either the level of costs, which could directly be identified with a particular service output, or the level of costs, which are unavoidably incurred in common with other services. Despite its shortcomings, the accounting costing approach is generally upheld as the cheapest and most convenient method, provided that data is available (Waters, 1997).

The second approach to costing is the Engineering Approach. According to Waters (1997), "the approach attempts to ascertain the relation between inputs and outputs by substantiating technical coefficients of the relations between inputs and outputs on mathematical grounds" (Waters, 1997). On the basis of these coefficients the approach attempts to combine the cost of those inputs to yield the cost function of the particular output. Two approaches exist for deriving technical coefficients. The first is to derive them from physical laws or precise engineering relationships. The second is to establish empirically the technical relationship by controlled randomised experiments. An example for the application of this approach, originally given by Waters (1997), is the estimation of fuel requirements for vehicles at different speeds. Controlled randomised experimental testing has proved that a linear relation exists between speed and fuel consumption.

The major shortcoming of the engineering costing approach is that it is data and time intensive and, therefore, it is a rather expensive and costly procedure. Another shortcoming with the approach is that it deals only with outputs and inputs, which are readily related in a physical way so that costs are necessarily traceable to outputs. It does not deal properly with situations where multiple outputs exist, such that specific cost output relationships are impossible to identify. For this reason the approach is generally regarded as unfit for the analysis of health and safety programmes.

The third approach to costing, which found extensive use in various evaluations is the statistical approach. Waters (1997) defined the approach as "the use of statistical techniques (usually multiple regression analysis) to infer cost output relations from a sample of actual operating experiences" (Waters, 1977). As the definition implies the approach makes use of data available from operating experience such as accounting information on patients' charges (possibly after adjustments such as disaggregating cost categories, re-evaluation of assets to equal their opportunity costs, etc.). According to statistical principles the sample of observations must consist of cost-outcome experiences relevant to the service being evaluated. For example, observations may consist of a comparison of surgical costs in different hospitals, over a period of time, or a cross section of the cost outcome experience of different services. Each of these sets of observations has particular advantages depending upon the purpose of costing but each also has disadvantages in that it may introduce systematic bias to the estimation of cost outcome relation (Waters, 1997). The degree of precision of results drawn by the approach depends on: the size of the sample; the fundamental predictability of the relation being investigated; correct specification of the variables measured; the accuracy of measurement; and the validity of the assumptions which underlie the statistical method employed. Though some economists argue that Statistical Costing is not an ideal method, it is largely regarded as a substitute for detailed engineering studies and/or controlled experiments, on the grounds that it is a less costly technique.

3.3 Cost Effectiveness Analysis Approach

Cost Effectiveness Analysis (CEA) approach is considered by economists as a full economic evaluation method where both the costs and consequences of the safety programme or intervention are examined. Some economists consider the approach as a variation of the CBA method (Steiner and Smith, 1973; Zerbe and Dively, 1994; Drummond *et al.*, 1998). Berman and Hanson (1994) define the approach as " a tool for combining information about the cost of an intervention with its anticipated health benefits". Steiner and Smith (1973) define it as "a methodological approach of identifying alternative solutions to a problem (or courses of action) in terms of costs and their effectiveness in attaining some specific objective". A more fluid conceptual framework reported by Steiner and Smith (1973) defines CEA as "any analytical study designed to assist a decision maker identifying a preferred choice from among possible alternatives".

It is clear from these definitions that the basic theme implied by the CEA criteria is that the programme's costs should be compared with the programme's outputs. The one that yields the lowest costs per unit of effect, compared with alternatives of similar or common effect, should be favoured and selected. According to its principles the CEA analysis can be performed on any alternatives, provided that they have a similar, or a common effect (Drummond, *et al.*, 1998). For example, heart transplantation could be compared to mandatory seatbelt legislation if the common effect of interest is the number of life-years saved. Effects or outcomes in CEA are usually measured in natural units, related to the objective of the programme, e.g. average blood pressure improvement in mm Hg, RTA deaths averted, lives saved, or life-years gained, provided that they constitute and end-point outcome. The results are usually expressed as cost per unit of effect (Drummond, et al., 1998). More recently, economists recommend the use of Quality Adjusted Life-Years (QALYs) as the appropriate basis for comparing programmes and interventions in CEA analysis (Drummond *et al.*, 1998). The ultimate goal sought by this change is to facilitate inter-comparisons between various programmes and thereby facilitate the assessment of public expenditure priorities. Viewed from a societal perspective, the criterion also implies that public resources should be spent on financing the production of services with the lowest cost per unit effect.

The challenge facing economists undertaking CEA analysis in disease or injury prevention is how to establish the evidence about effectiveness (Drummond *et al.*, 1998; Waters, 1997; Steiner and Smith, 1973). There are numerous methodological and practical challenges if the analysts were to rely on data derived from clinical trials (e.g. randomised-controlled trials, case-control trials or cohort studies), as is the case in most studies attempting to establish evidence in health and medicine. This is due to the fact that the design of most of these trials is seldom naturalistic. In the traffic safety field, where the effectiveness outcome evidence needed is the reduction in human injury from safety interventions such as speed limits for example, it is almost impossible to establish causality through experimentation for the obvious reasons of being illegal and unethical (Waters, 1997). Instead, the only procedure is to rely on measurements of associations supported by precision estimates, though it is known that such analyses do not control for other confounding factors and therefore do not guarantee causality.

However, an alternative procedure for establishing effectiveness, which has been recently recommended by economists, is to conduct an overview or *meta*-analysis of a group of trials. Although this by itself is complicated, it is further complicated by the reality that such overviews usually entail adjustments due to the fact that the output data of the reviewed trials usually vary from one trial to another. One recommendation made by economists to resolve the problem is to make assumptions about the evidence of effectiveness from the overview data and then to undertake sensitivity analysis of the economic results in accordance with these assumptions (Drummond, 1998).

In summary, the steps to conduct a CEA analysis involve the identification of a particular aim or objective. Often, the aim itself is set through a separate process that may or may not recognise the costs and benefits together. As explained in the preceding discussion, setting the aim will require establishing effectiveness. This by itself might involve an overview to the published data to establish the evidence about the effectiveness of the programme and thereby lead to undertaking sensitivity analysis to the final economic results. However, the majority of economists recommend that once the aim is set, analysts are required to review alternative approaches and choose those that will allow the aim to be achieved at the lowest cost. It remains to mention that many of the methodological techniques that have been proposed for operating the CBA method are equally important in the CEA evaluations. These techniques involve discounting the future costs of the programme, undertaking sensitivity analysis for the final results, evaluating human life, etc.

3.4 Cost Utility Analysis Approach

The Cost Utility Analysis approach (CUA) is an extension of the CEA approach, in the sense that both of them compare costs of programmes with their relative effectiveness. The two approaches are similar if not identical, on the cost side, but differ in the measurement of the outcome effect. As explained before the outcome effects in CEA are measured in natural terms, which are typically single, programme specific and unvalued (e.g. blood pressure reduction, cases cured). The approach designates the main outcome as the primary effectiveness measure and uses it as the denominator in the cost/effectiveness ratio. In the course of practise, economists realised that because the measure of primary effectiveness for outcomes may differ from one programme to another, the approach does not allow for comparison across a broad set of interventions. Further they realised that in any one programme there is often more than one outcome of interest and that those outcomes may be less or more important or less or more valued than others. Due to these concerns CUA was developed to enable the inclusion of the various disparate outcomes into a single composite summary outcome measure (Drummond, *et al.* 1998).

The measurement unit of effectiveness in the CUA approach is the *quality-adjusted life-years* (QALYs). According to Drummond *et al.* (1998), the concept first appeared in 1970 under the name of *function years* (Fanshel and Bush, 1970). Later on it was recognised that the *function years* gained are equivalent to 'additional quality adjusted years of life' (Bush, *et al.*, 1972). Thereafter, the concept became well established and popularised by the works of numerous economists including Torrance (1971), Torrance *et al.* (1972), and Weistein and Stason (1977). It is worth noting here that QALYs also go by other names. The Untied States National Centre for Health Statistics uses the term Years of Health Life (YHL) and the Canadian Health Statistics uses Health Adjusted Person Years (HAPY) and Health Adjusted Life Expectancy (HALE), (Drummond, *et al.*, 1998).

QALYs are based on a set of preference weights, known as utilities. The term utility is used here to denote the preference individuals or society might have for any particular set of health outcomes. They reflect the relative preference or desirability individuals place on each possible health outcome. A feature that allows, in Drummond's words, 'for *quality of life* adjustments to a given set of treatment outcome, while simultaneously providing a generic measure of comparison of both costs and outcomes in different programmes' (Drummond, *et al.*, 1998). This generic outcome, usually expressed as QALYs, is arrived at in each case by adjusting the length of time affected through the health outcome by the utility value (on a scale of 0 to 1) of the resulting level of health status. Thus the process converts the effectiveness data to a common unit of measurement combining the changes in the quantity of life (mortality) and the changes in the quality of life (morbidity) (Drummond, *et al.*, 1998).

QALYs estimates are made in various ways, including the standard gamble utility measurements, time-trade-off value measurements, visual analogue scale value measurements, estimates by physicians or researchers, or preference weighted systems like the Health Utility Index, the Quality of Well-being, or the EuroQol-5D (Drummond *et al.*, 1998). The most common among these is the standard gamble utility measurement. It attempts to obtain a linear ranking of health states by presenting the individual with a choice between a certainty of being in one health state and a 'gamble' of either being 'worse off' or 'better off'. The relative valuation of health states is obtained by varying the probabilities assigned to the gamble until the respondent is indifferent between the gamble and the certainty. The relative desirability of outcomes is measured using Von Neuman-Morgenstern utilities as the quality adjustment weights (QALYs).

The distinguishing feature of the CUA approach is that multiple health outcomes can be incorporated and the outcomes are not just counted, as the case in the CEA approach, but are valued according to their desirability. Additionally, the measurement (QALY) is general as opposed to the CEA programme specific measurement. QALYs also implicitly incorporate the notion of value.

It remains to mention that both CEA and CUA require valid effectiveness data from the literature (supplemented by sensitivity analysis). But in the case of the CUA only final effectiveness outcome data will suffice (e.g. lives saved, disability days averted, etc.). The techniques described for conducting a CEA evaluation equally hold for the CUA evaluations, including sensitivity analysis and discounting. Economists recommend a number of situations where the CUA should be used. The conditions include:

1. When the health related quality of life is the important outcome. For example if the issue of interest is how well the different treatment programmes improve patients physical function and psychological well-being.

2. When the programme affects both morbidity and mortality and the analyst wishes to have a measurement that combines both effects.

3. When the analyst wishes to compare a programme to others that have already been evaluated using CUA.

3.5 Cost Benefit Analysis Approach

We have seen in the foregoing discussion of the Costing approach, the CEA and CUA approaches that the evaluation of benefits has taken one of two forms: either a unique measurement specific to the programme as the case in CEA evaluations, or preferential utilities as in CUA evaluations. Although the latter approach employs standardised scales for measuring health benefits, which can be used to compare across health programmes, the broadest kind of comparison would be one in which all the costs and benefits are valued in the same unit (e.g. monetary values). In theory, one could then be able to determine among the competing programmes the one that is worth undertaking. The broadest method for conducting such analysis in health economics is the method of Cost Benefit Analysis (CBA).

It is generally upheld in economic theory that knowledge about benefits and costs is useful in decision making, especially under the existing constraints of budgetary expenditure and the scarcity of resources, which confront all societies in the world. Zerbe and Dively (1994) maintain that a public body aiming to maximise social welfare will take into account the social costs and benefits of individual projects as opposed to a private business firm, which takes into account its private costs and benefits only (Zerbe and Dively, 1994).

In principle, the CBA approach can be defined as a set of procedures for defining and comparing benefits and costs associated with a scheme over a long period of time and tries to quantify them by expressing them in a common monetary unit (Hardwick *et al.* 1994, Drummond, *et al.,* 1998, Zerbe and Dively, 1994).

The underlying principle of the technique, as pointed out by Hardwick *et al.* (1994), is to maximise social benefits in relation to social costs. Social benefits include all those effects of a policy change that increase social welfare, and social costs include all those that reduce social welfare. An increase in net social welfare can be regarded as equal to gross social benefits minus gross social costs (Hardwick *et al.*, 1994). Viewed in this way, cost-benefit analysis is an alternative technique for resource allocation in the public sector to that of allocation by the market mechanism, as will be explained in this section. It enables the decision-maker to choose from the alternative projects that maximise net social benefit. Economists contend that this narrow objective of the maximisation of net social benefit of a given project should in principle however, be consistent with the broader objectives of social welfare in the allocation and distribution of resources. Thus, the CBA approach can be regarded as a practical illustration of the uses and limitations of compensation tests.

However, an operational definition for CBA will better illustrate the principles of this approach. Drummond, *et al.* (1998) define CBA as a method of analysis that compares the discounted future streams of incremental programme benefits with incremental programme costs; the difference between these two streams being the net social benefit of the programme (Drummond, *et al.*, 1998). The definition implies that the goal of the analysis should be to identify whether a programme's benefits will exceed its costs; a positive net social benefit indicating that a programme is worthwhile and *vice versa*. An algebraic illustration of this definition will shortly be given in this section. An alternative formulation, also given by Drummond *et al.* (1998), is to consider whether the ratio of benefits to costs is greater than unity. However, this formulation is generally regarded as problematic because the location of items in the numerator or the denominator can easily change the resultant ratio.

The definition given by Drummond *et al.* (1998) for the CBA method is illustrated by the following formula:

Given i=1,......I possible investments:

$$\text{NSB}_i = \sum_{t=1}^{n} \frac{b_i(t) - c_i(t)}{(1+r)^{t-1}}$$

NSB_i	= net social benefit of project *i* (discounted).
$b_i(t)$	= benefits (in money terms) derived in year t.
$c_i(t)$	= costs (in money terms) in year t.
1/(1+r)	= discount factor at annual interest rate *r*.
n	= life time of the project.

Based on the formula the primary goal of the CBA method will be to identify projects that have an NSB>0. As shown in the formula, both costs and benefits of a programme under consideration will need to be identified, measured, valued and discounted to the present, in monetary terms.

To relate to the context of RTA evaluations, this will typically involve identifying, measuring, and valuing the costs of RTA consequences and the costs of introducing the safety measure, in one hand, during the life span of the programme; together with identifying, measuring, and valuing the benefits of the counter measure on the other hand, that is in addition to comparing the alternative safety measures in terms of both their costs and benefits. Both costs and benefits will have to be discounted during the life span of the programme to estimate the net present value of the programme. Although the illustration given here is based on a societal perspective, the formula, as recommended by Drummond *et al.* (1998), is also useful for allocation within a fixed budget to rank projects according to their NSB, if the analysis is based on a narrower perspective. .

It is worth noting here that results from the CBA method are regarded by most economists as an aid to thinking and not the decision itself which has to be made by decision makers and not as a consequent result of the analysis (Drummond, *et al.*, 1998). This is due to the fact that the CBA cannot be assumed to capture the thinking of the decision-maker. Further, it is established that the process of the quantification itself could impose limitations on the conceptual framework of the analysis. For example, it is known that the analyst's philosophical and normative assumptions about the specifications of rights on which to calculate benefits and costs will always remain embedded in the analysis.

3.5.1 **Rationale for Cost Benefit Analysis**

It is established that in a national economy the market mechanism alone cannot perform all the functions required to attain an efficient and equitable allocation of resources (Hardwick, *et al.*, 1994; Berman and Hanson, 1994). In essence, the market mechanism tends to give rise in several situations to a divergence between marginal private and marginal social costs and between marginal private and marginal social benefits; a situation which necessitates action by the government. These situations include the existence of externalities, existence of public goods and merit goods, monopoly powers, etc. The cause of the divergence is that some of the relevant benefits and costs in each of these situations are not considered by private decision-makers, as will be explained later in this section (Hardwick, *et al.,* 1994; Berman and Hanson, 1994; Zerbe and Dively, 1994).

Economists managed to develop the method of CBA as an aid or an alternative method of resource allocation, to assess and justify public expenditure priorities and governmental interventions. As such the application of the approach is believed to help the economy to attain social welfare, compared to that of the price mechanism. In the following section we shall attempt to explain and clarify, briefly, why an alternative technique for resource allocation, other than that of the market mechanism is needed. Why is a government or a societal perspective needed in a free market economy? What are the situations that entail government intervention? We contend that answering these questions will help to understand the theoretical underpinnings of economic evaluation in general and the rationale for the CBA method in particular.

To approach these questions we shall first give a brief account of the principles governing resource allocation in a free market economy under the hypothetical conditions of equilibrium before proceeding with allocation under market disequilibrium. This will typically involve identifying the basic economic problem encountered by human societies, the *Pareto* efficiency principles of resource allocation under perfect competition and the methodologies of economic analysis under the conditions of 'market failure'.

3.5.2 The Basic Economic Problem

In principle, human existence is preoccupied with the production and consumption of wealth, the desire for which seems to arise from man's basic impulse to increase his welfare (Hardwick, 1994). The production of wealth is vital because it enables individual and collective wants to be satisfied. Thus, there is no doubt that the concepts of *wealth* and *welfare* stand at the heart of economic theory. Wealth in any country consists of the stock of the country's resources, available for the production of goods and services. On the other hand, welfare refers to the satisfaction that individuals in the society can make out of wealth. Given the scarcity of a country's resources, the state of technology and the technical know-how available, the basic problem is of allocating these resources between the competing and virtually limitless wants of consumers in the society. The scarcity of resources in conjunction with the individuals' demands imposes on society the need to choose from the range of wants that can be satisfied. A decision to satisfy one set of wants will apparently have an opportunity cost on some other set of wants. Thus, it could be argued that the interaction between the scarcity of resources and the restricted choice forms the backbone of the mechanism for determining the amount of goods and services produced and distributed and therefore, the state of welfare available for the society. The basic task for all societies is thus to decide in some way *what* goods and services to produce, *how* to produce them and for *whom* to produce them.

Based on the principles of welfare economics, economists were able to develop techniques to judge whether the existing system of production and distribution about (a) the methods of production, (b) the types of goods and services produced and consumed and (c) the relative share of goods and services going to each household, satisfy the conditions of social welfare. These conditions require that society's productive factors of labour and capital attain an optimal level of *efficiency in* production and an optimal level of *equity* in the distribution (Hardwick, *et al.*, 1994). It is generally upheld that such a welfare situation might be said to exist when no rearrangement of the systems of production, consumption and distribution of wealth can increase the welfare of one person or a group of persons without harming the state of welfare of someone else. In other words, if a policy action to the prevalent system of production, consumption and distribution were to end up by increasing the welfare of one group without making anyone else worse off, it can be said that this is a definitive welfare improvement in the society as a whole.

However, economists realise that such a situation does not exist in real life due to the influence of scarcity and choice. The two factors influence the product mix of goods and services attainable by the society on the one hand and the differences in factor endowments (the relative mixture of cheap and expensive resources) among different societies which influence the combinations used to produce the chosen output mix at a minimum cost on the other hand. A further difficulty arises in measuring the relative gains and losses between individuals in the society from policy actions that influence production and consumption. It is evident that most welfare changes and policy actions impose gains and losses in the different segments of the society. To recall the words of Hardwick, *et al.* (1994), "if a theory existed that could tell the 'optimal' or 'ideal' distribution of income and wealth, it could have been possible to judge whether a given change in the distribution pattern would be socially desirable or undesirable" (Hardwick, 1994). There are no clear-cut rules, however, and so the problem of distribution or equity remains very controversial.

Thus, to sum up, given the scarcity of resources (labour, capital and technology), and the society's preferences, the fundamental economic problem all economies face will remain how to strike equilibrium between *efficiency* and *equity* in the allocation of resources in order to attain an optimal level of *social welfare* from the production, distribution and consumption of goods and services that comprises all individuals in the society. A criterion is thus needed to assess *efficiency* and *equity* in order to judge societal priorities and/or the possible effect of alternative policy measures aimed for increasing social welfare to the society.

3.5.3 **The Pareto Efficiency Criteria**

To approach efficiency and equity in resource allocation, economists separated the problems of efficient allocation of resources for production of goods and services from the controversial problem of distribution of income and wealth. The Italian economist Alfredo Pareto (1848-1923) concentrated on the efficiency aspects of welfare and the general principles of economic policy evaluation with less attention to distributional or equity issues (Hardwick, *et al.*., 1994). He developed principles, now carrying his name, for judging allocative efficiency, which are based on the following propositions of welfare economics:

- Social welfare is made up from the welfare (or utilities) of each individual member of society and it should comprise individuals' welfare.

- Individuals are the best judges of their own welfare (consumers' sovereignty) and as such they are considered the best source of information on their own welfare.

- Resource allocation is proceeding by the forces of a competitive market, which is in equilibrium.

- The current income distribution is appropriate and equitable.

On the basis of these hypotheses *Pareto* derived three conceptual conditions for economic efficiency, known as the Pareto efficiency criteria, to judge whether the society as a whole was better off from a policy or a government programme. These conditions, rephrased recently by Hardwick *et al.* (1994), include the following:

1. The given stock of resources must be allocated in the production of goods and services in such a way that no reallocation can increase the output of one good without decreasing the output of any other. When this condition is not satisfied, there will be room to reallocate the resources in such a way that some more goods will be produced without having to reduce the output of any other good.

2. The combinations of goods and proportions in which they are produced must be in response to the tastes and preferences of the community; i.e. the goods produced must be the ones that the community wants.

3. The distribution of goods and services must be in conformity with consumer preferences, given their tastes and incomes.

The efficiency produced by these conditions together is known as *Pareto* efficiency, which is attainable when no further changes to resource allocation can be made without harming someone else. The principles for judging that situation are known as the *Pareto efficiency criteria*, or the *welfare criteria*. According to these principles, a change from one position to another position in which the welfare of one person or group of persons is improved and no one else is harmed is called a *Pareto Superior Move* and is regarded as an action that increases social welfare. The welfare criteria can thus be viewed as method to judge policy actions and to decide whether a particular change in the way in which the production and distribution are organised will increase social welfare. To verify whether or not a given change possesses the characteristics of the *Pareto Superior Move* one need to examine the proposed programme or intervention in relation to the three prescribed conditions of *Pareto efficiency*. If the proposed measure is such that it will remove all the violations of these conditions and will have the effect of transforming a situation which is inefficient, in the *Pareto* sense, into one that is efficient without harming any one else, it will be considered as a *Pareto Superior Move* (or *Pareto* improvement) that will increase social welfare (Hardwick *et al.*, 1994).

The prominent discrepancy held against the welfare criteria is that in principle it dictates that if one of the conditions of efficiency cannot be fulfilled then the other conditions, although attainable, are no longer generally desirable. As such; it could be said that the efficiency criteria relate only to changes, which benefit someone without harming someone else. It has no concern with welfare consequences of changes that are not of this type – changes from which someone gains and someone else lose. Economists regarded this as a serious limitation of the efficiency criterion on the basis that the changes on which it remains silent are by far the most common (Hardwick, *et al.*, 1994). In the real world, most policy actions and reorganisation of production and distribution are such that some people benefit while others are harmed. The realisation of this fact has led economists to devise methods to determine whether any given policy change or action will increase or decrease social welfare. However, despite this limitation, the *Pareto* principles of efficiency remain at the heart of policy analysis aiming to maximise social welfare. These principles, despite being hypothetical, are commonly held by most economists as guidelines to approach efficiency. Among the methods that have been devised to test the effect of policy measures and programmes of intervention were the market failure approach and the compensation tests, which form the basis for the CBA approach. In the following section we shall briefly outline the basic features of these two approaches.

3.5.4 **The Market Failure Approach**

It has been stated before that in a real market economy the market mechanism alone cannot perform all the functions required to force the economy to attain an efficient and equitable allocation of resources. It has been proved that in the real world there are numerous conditions and impediments that justify government intervention in a market economy. These conditions are collectively referred to in the literature as 'market failure' conditions. They shape the structural organisation of every human society. These conditions refer to the forces that prevent the market mechanism (interaction of businesses and consumers) from functioning efficiently enough to produce an optimum efficiency that guarantees the maximum utilisation of a country's resources and the allocation of those resources to the entire satisfaction of the population. It is established that the price mechanism alone tends to give rise systematically to a divergence between marginal private and marginal social costs and between marginal private and marginal social benefits (Hanson and Berman, 1994). The reason for that, according to Zerbe and Dively (1994), is that there are benefits and costs that cannot be considered by private decision makers; a situation that necessitates an action to be contemplated by some exogenous power other than the market forces. In recent years governments have eventually become responsible for regularising the workings of the market economies with the implicit aim of attaining and sustaining social welfare.

These situations include: Firstly, the existence of public goods, merit goods and externalities. Public goods are those meeting two conditions: (1) joint consumption; and (2) high exclusion costs. Services such as traffic police, education and roads are examples of public goods, or goods for which consumption is non-rival (Hanson and Berman, 1994). These services are consumed in great lumps, and the consumers cannot easily be charged or excluded through the pricing system. It is evident that public goods cannot be provided by private sector or through market mechanism because the benefits of these goods cannot be attributed to individual users. Merit goods are goods and services, which we believe, have a certain value just because they are a good thing. Examples are public scenes, health care for the poor, etc. Due to the nature of these goods and services users can't easily be charged or excluded through the market mechanism. A situation that necessitates the provision of such goods and services by a government or a public body.

Externalities refer to the spillovers of the production system itself for which producers and consumers have no direct cost obligations (Elvik, 1994). Examples include RTAs, congestion and pollution that all production and consumption of transport services produce. Those external costs do not reflect directly on the production costs of individual producers or individual consumers. Their effects reach individuals instead of being restricted to the ultimate producer or user. Those situations constitute a case of market failure, which require governmental action to guarantee equity and allocation efficiency as well.

Secondly, the existence of monopoly powers. Monopoly powers have the ability to control prices and to prevent the free entry of firms into the industry; a case that violates one of the fundamental principles of free competition in market economies. Given the motive to maximise profits, monopolies are likely to set price above competitive levels, which will lead to misallocation of resources. To promote competitive conditions and to prevent potential abuse of monopoly powers, government action through anti-monopoly legislation, taxes and subsidies are usually required in most market economies.

Thirdly, the existence of information costs. In contrary to the principles of a competitive market, perfect knowledge about the prices of goods and resources is by no means a free good. In reality, there are considerable costs of information and search involved; and to the average consumer these may be prohibitive. At the same time, consumers lack information about the technical qualities of many goods and services. The same problems are encountered in the markets for resources. In the labour market for example workers are rarely fully aware of the wage rates and career prospects in rival firms and industries in the same locality or in firms and industries in different localities. Experience shows that in most market economies government actions were routinely motivated by concerns about imperfect information. This eventually led to the adoption of a series of legislation and regulations to eliminate false advertising that might harm consumers. An example is the maintenance of motor-vehicles safety standards through licensing motor vehicles. The argument is that it is costly for road users to get acquainted about the quality of motor vehicles and that licensing tends to guarantee a minimum quality standard.

These examples illustrate situations of market failure that entail public intervention. It is equally important that public intervention is essential in market economies where the market mechanism is prone to high unemployment, inflation and balance of payments difficulties. In such circumstances government intervention and action could help in implementing policies designed to achieve a high level of social welfare.

The rationale for government intervention, according to the market failure approach is that in the absence of public involvement, the market will tend to lead to outcomes in which there is either over or under-provision and consumption of these particular types of goods and services. Thus, one approach of assessing public expenditure priorities and resource allocation is on the basis of whether the goods or services fall into the categories mentioned above, leaving private markets to provide for the production and consumption of other services. But, again which policy action will improve the situation and which alternative policy might be the desirable one to attain efficiency and equity will entail a further analysis using the CBA method.

3.5.5 **Methods to Reconcile Efficiency and Equity**

It is clear from the foregoing discussion that, in practice, the production, consumption and distribution of goods and services are neither efficient nor equitable. It has already been pointed out that the *Pareto* efficiency criteria relates only to changes which benefit someone without harming anyone else. It remains silent about the most common changes from which some ones gain and some others lose. Furthermore, the *Pareto* criterion does not indicate how wealth and utility is to be distributed. Thus, we could contend that the criteria discussed so far, is incapable of judging an optimum social welfare that could be attained from an equitable and efficient utilisation of resources under the realistic 'market failure' conditions which characterise all societies. The realisation of this fact has led economists to device methods to determining whether any given policy change or action will increase or decrease social welfare? However, the *Pareto* principles of efficiency remain at the heart of policy analysis aiming to maximise social welfare. Among the methods that have been devised to test the effect of policy measures and programmes of intervention were the compensation tests, which form the basis for CBA approach. In the following section we shall briefly outline the basic features of these tests.

3.5.5.1 **Compensation Tests**

Based on the principles of *Pareto efficiency* which contend that a policy is efficient only if there are no losers, and that *Pareto efficiency* is reached when there remain no actions that make someone better off without making someone else worse off, the British economist Sir John Hicks and Lord Kaldor devised a method known as the Compensation Test (Hardwick *et al.*, 1994). The Kaldor-Hicks test attempts to determine whether or not a given policy change increases or decreases social welfare. It suggests that a useful benefit cost measure is one that ignores distributional effects. According to the approach as long as the gains from a policy exceed the losses (benefits exceed costs), the policy would satisfy the Kaldor-Hicks test. The method implies that there will be a net improvement in the welfare of the community if those who gain from a policy can place higher value on their gains than the losers place on their losses. Under such circumstances the gainers will have enough incentive and thereby could hypothetically agree to compensate the losers and still retain same gains for themselves. In practice, the test was used to judge potential improvement in welfare with little or no compensation being paid. It simply involves calculating the present value of costs and benefits and determining if the benefits exceed the costs.

The test was criticised on the basis that it ignores the distributional effects of policy changes or the equity considerations. However, Zerbe and Dively (1994) make two arguments for using the Kaldor-Hicks test. The first argument is that empirical evidence suggests that the costs of determining the distributional effects usually outweigh any distributional gains that might be made from attempting to incorporate distributional effects. For this practical reason they contend that distributional effects should be ignored. The second argument, originally developed by Musgrave (1969) and further strengthened by Zerbe and Dively (1994), suggests that the distributional effects should be ignored in project analysis where the gains from considering the distributional effects and of projects will probably be less than the costs of determining the distributional effects and of carrying out the redistribution (Zerbe and Dively, 1994). The argument is strengthened by the realisation that the process of economic development, that is of increasing the size of the total pie, often ends up increasing income equality (Zerbe and Dively, 1994).

3.5.5.2 **The Scitovsky Double Test and Little Tests**

Tibor Scitovsky and TMD Little, building upon the Hicks-Kaldor methods, suggested modifications to the Compensation Test approach that would reconcile both efficiency and equity from policy changes (Hardwick *et al.*, 1994). To justify a policy change, Scitovsky and Little suggested that analysts should confirm, at the outset, that the policy change satisfies the Hicks-Kaldor test. Second, they should confirm that the return to the initial position does not satisfy the Hicks-Kaldor test. The assumption is that both sets of tests operate on an open implicit value judgement and that no actual payment compensation is made. If compensation were paid there would be a welfare improvement in the *Pareto* sense. Little's contribution was centred on the inclusion of a criterion to check that the policy proposal does not affect adversely the distribution of income or wealth following the application of both the Hicks-Kaldor test and the Scitovsky test. By arguing that explicit value judgements should be attached to what happens to the distribution of income following a change in policy, Little thought that this could guarantee the incorporation of equity considerations into the social welfare function. Hardwick reckons that in practice, though, not all prescriptions have taken income distribution considerations explicitly into account. Instead, economists have frequently reverted to the Hicks-Kaldor test.

3.5.6 **CBA and the Compensation Tests**

Most economists regard the CBA approach as a practical illustration of the Kaldor Hicks compensation tests, with the programme benefits being valued using the principles of 'willingness to pay' values (Hardwick *et al.*, 1994; Drummond *et al.*, 1981, 1998; Zerbe and Dively, 1994). Based on the propositions of *Paretian* welfare economics, the purpose of CBA analysis is thus to identify *Pareto Improvements*; that is, situations where the maximum total sum of money that the gainers from a project would be prepared to pay to ensure that if the project were undertaken exceeds the minimum total sum of money that the losers from it would accept as compensation to allow it to be undertaken (Drummond, *et al.*, 1981). The perspective requires that benefits from the reduction of RTAs for example, be viewed in terms of consumers' willingness-to-pay rather than restricted to impacts on labour productivity, as compared to the HC approach. Additionally, those benefits should be high enough to ensure that gainers will be prepared to pay to losers from it (hypothetically) a satisfactory compensation (willingness to accept value) that would allow them to accept the project. Or put it more concisely, it is to determine what consumers who *gain* from a safety programme are willing to *sacrifice* to have the programme in question. It is this collective willingness to pay (willingness to sacrifice other goods and services) which is the focus of the CBA; recognising that not all consumers will benefit and some may lose and require compensation.

3.5.7 **Steps to conduct CBA**

According to Zerbe and Dively (1994), Drummond *et al.* (1998), and other economists the steps to conduct cost-benefit analysis are similar to those of policy analysis. Although it is not feasible to attempt constructing a generic model that specifies every step that would be involved in the analysis, it will suffice us here to outline the essential steps that might be contemplated in a CBA model. They can be summarised in the following points:

1. A CBA requires a clear purpose and perspective. That is to say, at the outset, the viewpoint of the analysis and of the analyst should be stated and clarified. An example given by Drummond *et al.* (1998) can best illustrate this. In the context of an evaluation of a health programme, an item might be viewed as a cost from one point of view, but not a cost from another. A patient's travel cost is a cost from the patient's and the society's viewpoint but not a cost from the Ministry of Health's viewpoint. Possible points of view include: society, Ministry of Health, other government ministries, the government in general, patient, employer, the agency providing the programme, etc. Therefore, it can be stated that the clarification of the viewpoint of the analysis is very crucial for the analysis to proceed. Furthermore, the determination of the body commissioning the analysis will give an additional clue for the relevant points for the analysis. However, economists consider the societal viewpoint as the broadest one and it is always recommended for analysts unless otherwise specified.

2. The aim and objectives of the analysis should be set out and clarified. The aim will define the problem while objectives will lay out how it can be treated as a practical matter. Objectives usually give an operational definition to the aim.

3. When considering an evaluation of a programme, imagination should be used to lay out as many alternatives as feasibly possible. Some of these alternatives can often be dismissed easily, but a review reduces the chances of ignoring superior alternatives. The costs of each alternative will need to be identified, measured and valued. Costs common to both programmes under study can be

eliminated, as they will not affect the choice between the comparative programmes. The relative order of magnitude of the cost item should be considered and analysed to avoid wasting time investigating costs that might make no difference to the final analysis. However, if it is thought that at some later stage a broader comparison may be contemplated including other alternatives not yet specified, it might be essential to consider all the costs of the programme.

4. The analyst will need to identify and measure the possible outcomes of each alternative programme. This step would involve a choice of techniques for predicting physical outcomes. In health and safety fields, in the absence of a definitive outcome for the programme under consideration, the identification of health and safety outcomes can be achieved through quantitative or qualitative trials (e.g. alongside randomised-controlled trials, case control studies, and retrospective analysis of time series data, etc). An issue that would raise the question of how long should the outcome treatment or intervention be traced? The analyst would apparently need to consider a choice of time period because that would reflect on the total costs of the programme. However, agreement is unanimous among economists that the choice of the time period should not bias the analysis. This step involves also the measure of effectiveness of the health programme and its other attributes.

The obvious choice for the main measure of effectiveness would be deaths averted or life-years gained. Life years gained is mostly preferred but would require assumptions to be made about the likely life expectancy of individuals undergoing the programme. Other relevant attributes for the programme could include:

- unpleasantness of the programme approach;
- complications (e.g. bleeding, pain, etc.) from the intervention;
- prolongation of hospital stay or rehabilitation period.

An alternative approach would be the use of an intermediate effectiveness measure, such as the number of cases averted, if the analysis involves a preventive programme (Drummond, *et al.*, 1998). However, the analyst will need medical evidence on the outcomes of each alternative, generated by controlled clinical trials as a first priority or by any of the other analytical techniques stated above.

5. The analyst needs to decide a possible technique for valuing the possible physical consequences. This, of course, is part of the heart of benefit-cost analysis. In the health field, the valuation of outcomes, once identified and measured, can be achieved through the use of official charges and market wage rates (for cost items like volunteer time and loss of productivity) or by using the exiting market prices. In the absence of market rates, an alternative approach, is the use of shadow prices and sensitivity analysis. Adjustment of market rates might be recommended, owing to the imperfections in health care markets. The outcome data once identified and measured can be combined with the cost data to give the total cost. Finally discounting, using the *social rate of time preference*, must be applied to adjust future costs and benefits to the present value.

6. An examination of the certainty of the predicted consequences is essential. Outcomes are always uncertain and this issue should, therefore, always be explicitly addressed. The prominent approach is to use sensitivity analysis.

7. What is the choice? This step draws together the results of the cost-benefit analysis and the predictions that underlie it, along with other perhaps political considerations relevant to the choice. This step is for the analyst who recommends the choice to the decision-maker.

8. What is the decision? This step is for the decision-maker who may be someone other than the analyst.

9. How do the outcomes compare with the predictions? The analyst should monitor the outcomes, compare the actual results with those predicted, and consider why the results may be different.

3.6 Conclusion

Economists have derived a number of scientific methods to judge societal priorities and the possible effects of alternative policy actions aiming to increase social welfare. Those methods include Cost-Benefit Analysis (CBA), Cost-Effectiveness Analysis (CEA) and Cost-Utility Analysis (CUA). The three methods are generally considered by economists to fulfil the criteria for economic evaluation, i.e. they have the capability of identifying, measuring and valuing the direct and indirect costs and benefits of all possible alternatives under consideration. The three approaches treat the cost items in similar manner but they differ in the way they measure and value the consequences and benefits of alternative programmes. Apart from the CBA approach, which consider fully and measure in monetary terms the programmes' benefits, the latter approaches, the CEA and the CUA approach, differ in the extent to which they measure the benefits. The CEA approach measures the programmes' costs with programmes' outputs. The one that yields the lowest costs per unit of output (effect), compared with alternatives of similar or common effect, is usually favoured and selected. The approach does not require the monetisation of the benefits or the output effects. Instead, they can be measured in any natural units, provided that they have a common or an equal end-point effect (e.g. number of years gained, RTA deaths averted, etc.). The ultimate theme of the approach is to facilitate inter-comparisons between various public expenditure priorities. The projects that yield the lowest cost per unit effect are usually selected. Thus, the major shortcoming of the approach is that it does not allow for comparisons between different programmes due to the restricted nature of the output measure unit.

The CUA approach is an extension of the CEA approach. Initially, both methods compare programmes' costs with their relative effectiveness. The difference between them rest in the measurement of the output effects. Instead of measuring them on natural units the CUA translate output effects into QALYs. The method is intended to enable the inclusion of various disparate and multiple health outcomes into a single composite summary output measure. Thus, the advantage of the CUA approach is that outcomes are not only counted, as in the CEA approach, but they are also measured and valued using Von Neuman-Morgenstern utilities as the quality adjustment weights (QALYs).

The CBA approach attempts to define, quantify and measure benefits and costs of alternative programmes over a long period of time in a common monetary unit with the intention to maximise social benefits in relation to social costs. Illustrated technically, the approach compares the discounted future streams of incremental benefits with incremental programme costs; the difference between these being the net social benefit of the programme. Thus, the approach consider whether the programme benefits exceeds its costs; a positive net social benefit indicating that the programme is worthwhile and *vice versa*. Because of its societal perspective the approach is considered by economists as an aid or an alternative method of resource allocation that assess and justify public expenditure priorities and governmental interventions compared to that of the price mechanism. The CBA approach is regarded by economists as a practical illustration of the Kaldor Hicks compensation tests, with the programme benefits being valued using the principles of WTP. The steps to conduct the CBA analysis are similar to those of policy analysis.

Compared to the CEA and the CUA approaches the CBA approach is of a broader perspective. The fact that the CBA approach measures the costs and outcome effects in monetary terms, reveals that the approach is not restricted to comparing programmes within the health and safety fields only but can be used to provide information about resource allocation both within and between the different sectors of the economy. Therefore, it enables addressing questions of allocative efficiency because it assigns relative values to health and non health related goals to determine which goals are worth achieving, given the alternative uses of resources and thereby determining which programmes are worthwhile. In contrast the CEA/CUA is essentially restricted to comparing programmes that produce similar units of outcomes such as QALYs. Or in other words, CEA/CUA address mainly questions of efficiency within the health and safety fields only.

Other methods of economic evaluation include the Cost Minimisation Analysis (CMA) approach and the Cost Analysis approach. CMA is viewed by many economists as an extension or a special form of the CEA approach where the benefits or output effects are considered to turn out equal and, therefore, the evaluation is essentially a search for the least cost alternative. Three approaches exist to conduct Cost Analysis: the Accounting Costing, the Engineering Costing and the Statistical

Costing. Discounting need to be conducted to adjust future costs to the prevailing levels.

In summary, it is very difficult to outline one standard formula of economic evaluation as the ideal one to judge the analysis. Firstly, there are varying perspectives, depending on the role expected by the analyst or his clients from the evaluation. A societal perspective is apparently favourable than sectorial or institutional ones, especially when considering the various aspects of costs and outputs that have to be included in the study and when considering questions of allocative efficiency within the economy. Secondly, measurement difficulties might compromise any analytical approach. Finally, the way in which each component is measured may influence the measurement of others and also the way in which the various components are assembled in the analysis. However, a guideline, when deciding the appropriate approach, implicitly recommended by Drummond *et al.* (1998), is that one should consider whether the breadth of the question posed entail the analytical effort that has to be made by using any of the four different formulas.

CHAPTER 4

METHODOLOGICAL ISSUES IN THE APPLICATION OF THE CBA APPROACH

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METHODOLOGICAL ISSUES IN THE APPLICATION OF THE CBA APPROACH

4.1 Introduction

The steps to conduct CBA analysis, which have been described in the previous chapter, apparently involve methodological techniques that have to be illustrated. These techniques are imperative for the CBA method to be operationalised. In the following sections, we shall explain and discuss firstly, the use of shadow prices in the estimation of programmes' costs and benefits, the use of financial tools in discounting the future values of costs and benefits to the present, in addition to explaining the methods for treating uncertainty in the analysis. These methods are clearly essential for the analysis of the future losses incurred by the society due to premature deaths and the numerous disabling outcomes that result from RTAs. Lastly, a conclusion will be made.

4.2 Shadow Price

The existence of public goods, externalities and monopolistic elements in market economies means that the prevailing market prices do not reflect the true social marginal cost of resources in alternative uses; which, according to principles, form the basis of competitive market rates. Additionally, relating to evaluations in health care and safety, there are many non-market resource inputs, which do not trade in observable markets. For instance, the journey time saved by drivers and passengers as the result of building a new road, savings from the reduction of RTAs or volunteer time and patient family time. For such non-marketed good, according to principles, the consideration should go to the use of alternative shadow prices. Zerbe and Dively (1994) define Shadow Price as "an accounting price that reflects an estimate of the opportunity cost of providing or eliminating an additional unit of the good"..
Drummond *et al.* (1998) defines shadow prices as 'imputed prices designed to reflect the 'true' social costs and benefits of a project' (Drummond, *et al.*, 1998). Two methods attaching shadow prices, in health care evaluations, exist. The first is the

opportunity cost of time approach, and the second is the *market replacement method.* The opportunity cost of time approach attempts to place value on household productivity, volunteer time, family and patients time by using the market wage rates to compensate for these activities, on the basis that this is the price an employer would pay to buy others time. The argument is based on the fact that the leisure time of labour is customarily valued at a rate as great as what could be earned in the labour market, or otherwise the labourer would choose to stay at home. Hence, the time would be valued according to the wage-rate forgone. A second approach, known as the *market replacement* approach, attempts to quantify how much it would cost to replace for such activities with the services from the market (e.g. gardening, cleaning, child minding, etc.). Both of these approaches have been used to value non-marketed or un-priced goods and services.

4.3 Discounting Future Values to the Present Value

4.3.1 Introduction

The present value of an asset is the market value of an asset today; while the future value of an asset is how much it will worth at some specified time in the future. But how are these to be compared? Discounting is meant to measure the present value of future costs and benefits of projects under evaluation. To illustrate the approach of estimating the present value of future costs and benefits we will follow the steps of Zerbe and Dively (1994). We shall start with considering, first, the principles applying to the interest rate in a hypothetical competitive market, a market in which economic efficiency conditions are met. These principles could then be generalised to a more realistic situation, or a market in which efficiency conditions are not met.

4.3.2 Discounting Under Conditions of Market Equilibrium

4.3.2.1 Determining the Discount Rate

According to economic principles, in a competitive market, the present value of future returns on capital investment must be less by a rate equivalent to the investment rate of return on capital; i.e. the interest rate or, in other economic terms, the social opportunity cost of capital (SOCR). When these funds represent lost consumption, the appropriate measure is the "social rate of time preference (SRTP)". SRTP represents the collective marginal rate of time preference (MRTP) of individuals, which measures the willingness of individuals to sacrifice present consumption for future consumption or (investment). On the other hand, SOCR represents the collective marginal opportunity cost rate (MOCR) which measures the opportunity cost of consumption today as equated to the loss of additional consumption next year (returns on investment). In an economy with perfect competition, with no market costs, no uncertainty or risk and taxes, *Pareto efficiency* requires that, the process of substituting consumption to investment at MRTP (the rate of interest of consumers) continues until MRTP equals MOCR; i.e. until no gains could be expected out of substituting consumption for investment. This stems from the fact that efficiency requires that if MOCR > MRTP there will be Pareto optimal trade through which gains will be realised. The process will continue until no further gains could be expected, or until MOCR = MRTP.

Since it is established that in equilibrium conditions efficiency requires that MOCR and MRTP be equal for each individual in the society; the results can be generalised to the entire society. Thus, the condition for efficiency in perfect market equilibrium will require that SRTP equal SOCR for all time periods and commodities. Therefore it could be stated that in an economy with perfect competition the rate of interest will be the market rate and this rate would be equal to both the SRTP and the SOCR. Accordingly, future values in a perfect market equilibrium, whether returns or expenditure, should be discounted to the present value using SRTP, SOCR or the market rate of interest to decide whether these values are as great as the market rate of interest. The mathematical procedure involved in calculating the present value of future returns at a given time is called, in the literature, "*discounting to the present*" and the interest rate used in the process is called the *discount rate*. The discount rate is an estimate of how rapidly the value of money changes during a time period in question. The decision about the rate to use is often a difficult task and will be dealt with in a later section of this chapter. The fundamental equation for discounting the present value in a competitive market is the following: (Drummond *et al.*, 1998; Zerbe and Dively, 1994; Van Haut, 1998).

$$P = {F_i}/{(1+r)^t} \qquad (1)$$

where:

P = the present value of the investment;

F_i = the future amount of the investment;

r = the interest rate (discounting rate);

t = the duration of the investment.

On the basis of this fundamental equation the Present Value of future costs and benefits could easily be generated at any given future time period once the interest rate or the discounting rate is determined.

4.3.2.2 **Annuitisation of Future Costs**

Since most financial situations involve a series of payments or yields at fixed intervals, e.g. investments on stocks, auto loans, bonds and securities, mortgages, pension schemes, estate rentals; or future costs and expenditures such as medication and rehabilitation of RTA victims, it is essential to illustrate the procedure for calculating their present values. The aggregation of the present value of these types of future cash flows is usually simplified by using *financial series formulas* instead of equation (1) above (Zerbe and Dively, 1994). These series differ in respects of their compounding factors including interest rates, interest periods, payments intervals, maturity periods, etc. A number of formulas and combinations of formulas are frequently used to quantify the present and future values of financial series, such as the forgone earnings due to premature death from RTAs.

4.3.2.3 **Discounting Formulas of Financial Series**

In general, if the financial series involves a stream of fixed amounts of payments denoted by A, made at fixed time intervals (ends of nth periods) for a given time period (nth year), at a fixed interest rate, the present value of such a series can be calculated by using the formula for uniform time series or annuities (Zerbe and Dively, 1994):

$$P = \frac{A}{1+r} + \frac{A}{1+r^2} + \frac{A}{1+r^3} \dots\dots\dots \frac{A}{1+r^{n-1}} + \frac{A}{1+r^n} \qquad (2)$$

Which could be reduced to:

$$P = \frac{A\left[1-(1+r)^{-n}\right]}{r} \qquad (3)$$

The quantity in brackets is known as *uniform series present worth factor* and is usually denoted by (P/A, or r%).

However, sometimes a financial series may grow by a uniform percentage or gradient each year. For example, payments on pension schemes might yield an increasing benefit every year. Another example is individuals' earnings, which increase on annual basis by a fixed increment. If these earnings cease to exist due to a reason such as premature death from RTAs, the quantification of losses to those individuals will need to be made taking into consideration the differential change made by this factor. These types of series are called a *uniform growth series or a geometric series*. They are based on the following assumptions:

1. Successive payments differ by the factor (1+g), where g is the productivity growth rate. The basic amount of the series is X, so the first payment is $X(1+g)$, the second is $X(1+g)^2$, and so on.
2. The interest r is constant.
3. Payments are made at the end of fixed periods.
4. A total of n payments are made. The final payment is thus $X(1+g)^n$.

The uniform growth series therefore consists of the following payments:

$$X(1+g) + X(1+g)^2 + \dots\dots\dots\dots\dots X(1+g)^{n-1} + X(1+g)^n \qquad (4)$$

If we use equation (1) to discount the present value of each of these payments we see that the present value P is :

$$P = \frac{X(1+g)}{1+r} + \frac{X(1+g)^2}{(1+r)^2} + \ldots\ldots\ldots\ldots + \frac{X(1+g)^{n-1}}{(1+r)^{n-1}} + \frac{X(1+g)^n}{(1+r)^n} \quad (5)$$

This could be eliminated by using an effective growth rate *k*, to combine both the effects of growth and discounting, such that:

$$1+k = {}^{1+r}\!/_{1+g} \quad (6)$$

Substituting equation (6) into equation (5) would yield:

$$P = {}^{x}\!/_{1+k} + {}^{x}\!/_{1+k}{}^{2} + {}^{x}\!/_{1+k}{}^{3} \;\ldots\ldots\ldots + {}^{x}\!/_{1+k}{}^{\text{n-1}} + {}^{x}\!/_{1+k}{}^{\text{n}} \quad (7)$$

Compared to equation (2) for annuity, the two forms are analogous and therefore the equation to calculate the present value of a *uniform growth series or a geometric series* can be given by:

$$P = \frac{A\left[1-(1+k)^{-n}\right]}{k} \quad (8)$$

By carefully examining the financial problem under consideration, one could easily combine any of these formulas, i. e. the single payment formula with the annuity formula and the gradient formula, to solve the problem in question in a straightforward manner.

4.3.3 **Discounting under the Conditions of Market Disequilibria**

But since economies do not operate in an idealised market as explained earlier due to the existence of inflation, uncertainty, effects of monopolies, and other externalities which affect the market interest rate or the SRTP, the consideration goes to an imperfect market rather than a competitive one. According to the economic literature, in a true market economy, the best approach would seek to maximise the discounted value of social welfare taking into account the market failure conditions. To extend the procedures developed for discounting under competitive market conditions to more realistic situations, consideration should be made to incorporating the external effects, of inflation, uncertainty, taxation, and the natural growth rate in the interest rate. Since we are bound, in the context of this study, to discount to the present the future RTA costs we shall restrict ourselves to the incorporation of inflation, taxes, uncertainty and the natural growth rate in our discounting model. In the following section a brief account will be given for the procedure to incorporate inflation, taxes, uncertainty and the natural growth in discount rates.

4.3.3.1 **Treatment of Inflation**

Inflation refers to a general rise in future prices throughout the economy. A general decrease in prices throughout the economy is referred to as *deflation*. It is established that, over time the average price level of commodities and services tend to increase due to several reasons including structural economic changes as well as changes in elasticity of supply and demand. Economists differ as to which ones are the most important but the discussion for that goes beyond the scope of this study. However, due to the effects of inflation, the estimation of future benefits and costs usually require accurate estimates of future cash flows and discount rates. For example, future costs of medication and rehabilitation of RTA victims are almost certain to increase over time and, therefore, need to be adjusted for inflation to reflect a realistic estimate for these costs. Future estimations of lost productivity for RTA deceased victims need also to be adjusted for inflationary effects and the natural growth rate to reflect a more realistic figure.

According to principles, to account for inflation, cash flows and discount rates can be expressed in one of two ways (Zerbe and Dively, 1994). A *nominal amount* which includes all the effects of inflation and thus is not directly comparable from one year to the other or a *real amount* after discounting for inflation, so that the purchasing power becomes reflected in real terms regardless of when it has been earned. Similarly, interest rate can either be expressed as a *nominal interest rate* which includes both the time value of money and the effects of inflation, and therefore, cannot be compared from one year to another, or a *real interest rate* which reflects only the time value of money, not changes in the general price level.

According to principles, either nominal or real values can be used in comparing future benefits to future costs in benefit-cost analysis, as long as they are used consistently (Zerbe and Dively, 1994). That is, nominal cash flows require nominal discount rates, and real cash flows require real discount rates. Both methods of accounting for inflation are acceptable so long as one is used throughout the entire analysis.

To be able to adjust the discounting rate for inflation, one will need to have a measure for the rate of inflation. Several measures of inflation exist; the most important of them are the GDP deflators, the consumer price indexes, and the producer price indexes (Zerbe and Dively, 1994). The first group of measures, the GDP deflators, includes changes in the prices of all goods and services in the economy. The GDP deflator, measures inflation implicitly by calculating the nominal GDP at current prices, and then by calculating the real GDP at the prices that prevailed in some earlier base year.

Since it is realistic to estimate all purchases and sales of individuals in an economy for a current and a base year, statistical sampling is customarily used to aggregate the purchases of goods and services, at current market cost for certain categories and then to deflate them at a base year cost. The ratio of the nominal GDP to the real GDP, or the GDP deflator, provides an index for the price change from the base year to the present year, and thus the inflation rate. Another GDP deflator under common use is the personal consumption expenditures (PCI) index, which measures the change in the prices of goods and services purchased by individuals (Zerbe and Dively, 1994). The second major group of inflation measures are the consumer price indexes (CPI). These indexes measure the prices of a fixed basket of market goods and services purchased by consumers, including food, clothing, housing, medical care, and a variety of other items. The ratios of the prices of this market basket in different years provide a measure of inflation. Since its calculation is based on a fixed set of categories, it gives only the pure change in price level and not the mix of purchases. Several types of CPIs exist, including the CPI for all urban consumers, known as CPI-U; CPI for urban wage earners, CPI-W, etc., and each has specific relevant use. The third common measures of inflation are the producer price indexes (PPI). These price indexes provide measures of price changes for private industries and are analogous to the consumer price indexes for individuals. According to Zerbe and Dively (1994) three types of PPI are available: measures by state of processing; measures by industry; and measures by commodity that reflects price changes for different materials (Zerbe and Dively, 1994). Estimates of PPIs are derived in a similar way to the CPIs, and their uses depend upon the relevant purpose and subject of analysis.

The guideline for the measure to use among the ones described above depends on the nature of the subject of analysis. However, the following guidelines, originally stated by Zerbe and Dively (1994) will help directing the analyst: Firstly, a measure selected should reflect the relative price facing the project or the issue under consideration. Secondly, it should be appropriate for the region in which costs will be incurred. Thirdly, it should correspond to the types of economic activity involved (Zerbe and Dively, 1994). A project that directly affects consumers should be evaluated using a version of CPI for example. If it will affect many sectors of the economy the GDP deflator should be used. If affecting an industrial sector, a version of PPI should be used, etc. Since RTA costs directly affect individual victims as well as the whole society, and since the cost items involved usually extend to different sectors of the economy, the GDP deflator as well as the CPI could be used for the analysis of RTA costs.

4.3.3.2 **Taxation**

Taxes can also have a similar effect on interest rates and future cash flows like inflation. Tax rates historically are imposed on nominal income and nominal corporate revenue; or in other words the tax system does not remove the effect of inflation when calculating tax payments. Taxes are thus another cost for most investments. The consideration of the methods to incorporate the effects of taxes and inflation in the models used for aggregating the present value in a true market economy will make our analysis of future benefits or costs more realistic. However, since the UAE is a tax-free economy the effect of taxation will not be considered in this analysis.

4.3.3.3 **Empirical Estimates of the Discount Rate**

To proceed with our subject issue then, the production that is lost by RTA victims as well as the other costs that must be incurred to restore them to their pre-accident physical and material well-being, can be considered as a measure of the consumption that is lost or (diverted to no-net gain uses) to the injured parties and their dependants. Hypothetically, it could be argued that the portion of these lost earnings, if invested rather than consumed, would represent foregone capital investments. Therefore, they should be discounted at a rate that reflects the social opportunity cost of capital. Or, on similar grounds, it can be argued also that such losses represent forgone consumption to the society and should be discounted at a rate that reflects the social rate of time preference (SRTP).

Although economists agree upon the necessity to discount future costs, there is considerable controversy about the appropriate rate to use. However, there is general agreement that the appropriate basis for determining discount rates is the marginal opportunity cost of lost or displaced funds (Blincoe and Faigin, 1994). When these funds involve capital investment, the marginal real rate of return on capital must be considered. However, when these funds represent forgone consumption to the society, as the case with RTA losses, the appropriate measure is the rate at which society is willing to trade off future consumption for current consumption. This is referred to in the literature as the social rate of time preference (SRTP) and it is generally assumed that the rate of interest, i.e., the after tax rate of return on widely available savings instruments or investments opportunities, is the appropriate rate to use. The productivity that is lost by individual RTA victims as well as the cost of medication and rehabilitation can be viewed as a measure of the consumption that is lost (or diverted to no-net gain uses) to the injured individuals and the society. It could be argued that the amounts lost, if invested rather than consumed could have earned interest returns; and therefore, they can be viewed as forgone capital investment. As such, they should be discounted at a discount rate that reflects the opportunity cost of capital. Therefore, forgone consumption is a dominant consideration in establishing a discount rate for RTA costs, and the social rate of time preference (SRTP) is the appropriate measure or rate for discounting.

In practice, most economists identified the SRTP with the after tax real rate of return on safe investments. Robert Lind (1982) estimated that the SRTP is between 0 and 6 percent, reflecting the after tax rate of return on treasury bills and stock market portfolios. Kolb and Sheraga (1991) put the rate between 1 and 5 percent based on returns to stocks and three-month treasury bills. Moore and Viscusi (1990) calculated a two percent real rate of SRTP for health, which they characterise as being consistent with financial market rates for the period covered by their study. Moore and Viscusi's estimates were derived by estimating the implicit discount rate for deferred health benefits exhibited by workers in their choice of job risk (Moore and Viscusi, 1990).

With the exception of Moore and Viscusi, most economists have followed one of two conventions to choose the discount rate (SRTP). Firstly, some economists used the historical rates of return on safe investments as a basis for estimating SRTP. Inflation adjusted interest rates on various bonds, treasury bills and common stocks were used by these analysts as a proxy for SRTP in future years.

One problem with using these instruments is the variability in the rates of return over time. It has been proved that the time period on which the estimate is based and the type of investment instrument itself can significantly influence the final result. The study conducted by NHTSA (1994) showed that estimates based on the performance of real after tax returns on *stocks* reveal considerable variations. An example, given by Blincoe and Faigin (1994), in the NAHTSA report will best illustrate this. The use of real rates of return estimates based on the performance of stock markets in the US in 1985, as a proxy for SRTP, showed a 10.7 percent rate; based on the previous 5 years it showed a 4.7 percent rate; based on the previous 10 years it showed a 1.9 percent; and based on the following five years it was 8.1 percent. Long-term cumulative averages showed similar variations. For the 51 years from 1940-1990, real rates of return on stocks averaged 4 percent. As the period examined decreases, returns rise slightly but then dip to a low of 1.5 percent for the 20 years from 1970-1990. During the 1990s, returns have averaged 5.6 percent and during the last 6 years, they have averaged 8.1 percent. The study revealed that treasury bills have more stability than stocks, but they were less attractive for average investors. Although individual years showed significant variations, historically they have given average negative returns of less than one percent. It appears from the study that investment on treasury bills is essentially to maintain current wealth rather than to increase it. The higher rates of return from stocks are reflected in consumer investment patterns, which is five times higher in stocks compared to treasury bills. Because of that, the study implicitly concluded that the past performance of treasury bills could hardly be taken as a proxy for estimating MRTP.

The effect of inflation also appears to pose a real problem with using the historical rates as a proxy for estimating SRTP. The actual inflation rates may not match the expected rates. As proved by Lind (1982) during periods of high and rapid inflation investors tend to understate the rate of inflation and might end up understating their MRTP, achieving negative real rates of return on their investments. But when inflation levels down or become modest, investors tend to overestimate inflation, ending up by overstating their MRTP and the real rates of return on investment (Lind, 1982). The study concluded that the best way to approximate SRTP is to examine rates over a long period of time. This allows temporary fluctuations to offset each other and gives less weight to isolated fluctuations that are not balanced out by cyclical response.

The second convention in choosing the discount rate, pointed out by Drummond *et al.* (1998), is that, in jurisdictions (like the United Kingdom) where the government announces a common discount rate for all public sector projects, the advised rate is used. Alternatively, where there is no announced rate the convention is to use a rate consistent with the existing literature. A 5 percent rate was used by a number of analysts publishing articles in the *New England Journal of Medicine* in the late 1970s and early 1980s and this became the *de facto* convention for economic evaluations in the health care field (Drummond *et al.*, 1998).

4.4 The Impact of Uncertainty and the CBA Approach

4.4.1 Theoretical Background

Economists define uncertainty as a sequence in our ability to foresee or foretell the future (Zerbe and Dively, 1994). In financial analysis, this implies that no future predictions could be made with absolute certainty. The reason is simply that the world is fraught with uncertainty.

Another source of uncertainty is the failure to measure with a high degree of accuracy the variables of interest. For example, one of the major sources of uncertainty in the analysis of RTA costs is the precision of the data available for the study. As mentioned before the data sources for many elements of RTA costs are usually non-sampled deterministic data that can be conceived only through informed guesses or by recourse to experts' panels. Elements such as RTA police administration costs, legal costs or traffic delay can only be achieved through qualitative methods like reviewing experts' opinion. Additionally, many other secondary data sources, e.g. the official cost estimates of overhead medical expenses, remain open to controversy and criticism regarding their precision. Finally, the discount rate, the rate of inflation and economic growth, that are to be used by the study, are additional sources of uncertainty.

To allow for uncertainty, a complete analysis of costs or costs and benefits will need to go a step further and test the results of changes in each of the cost elements (variables). According to Zerbe and Dively (1994), three approaches exist to cope with uncertainty. The first is simply to ignore its effect if its level is small, or the time span for the analysis is short or where the analysis is intended only as a rough estimate. The second approach is to reduce uncertainty to levels at which it can safely be ignored. The final approach is to recognise uncertainty and to factor it into the analysis. According to principles, three categories of techniques exist for exploring uncertainty in financial analysis, namely: Sensitivity Analysis; Simulation; and Decision Trees (Drummond, *et al.*, 1998; Zerbe and Dively, 1994). While a full detail of the first approach will be made in this section later, we shall first start by a brief explanation for the two latter approaches: Simulation and Decision Trees.

Zerbe and Dively (1994) regard simulation as an outgrowth of sensitivity analysis. However, many simulation techniques are available for use in financial analysis, ranging from simple techniques to extremely complex and time-consuming ones. The most famous among them is the computer based *Monte Carlo* simulation technique. It considers many possible combinations of variables rather than a few estimates or a few scenarios to test for uncertainty. It is usually considered as a powerful analytical approach. The approach involves employing a computerised model based on equations showing the relationships between the different variables. The model repeatedly tests for interactions between the different variables on the basis of the probabilities of the different results for each of the variables. The resultant probability distributions are ultimately sampled to calculate the resulting cash flows. Theoretically, the approach looks superior, being supported with computer based model capable of allowing for many combinations of variables to be tested and explored. Thus, it produces results, which might reflect all possible interactions and combinations among variables, which could be unattainable by any other analytical procedure.

Unfortunately, that is not the case in practice. Economists contend that the approach suffers from three disadvantages (Zerbe and Dively, 1994). Firstly, it is difficult to prepare good probability estimates for each variable. Secondly, it is also difficult to develop equations that reflect all possible outcomes and interactions between these outcomes. Thirdly, it requires a great deal of data and information which makes it time consuming and expensive. In view of these limitations, the simulation approach might best be suggested for relatively complex projects that need very careful consideration and analysis. Most economists suggest that it is unsuitable for the analysis of uncertainty in projects such as the estimation of RTA costs (Zerbe and Dively, 1994).

4.4.2 **Decision Trees**

Decision trees are one of the techniques used for analysing uncertainty. Again, according to Zerbe and Dively (1994), the approach begins with a graphic presentation of the different possible outcomes of a decision and then uses probability analysis to calculate the overall expected value of the project where the different options for a project are analysed in sequential basis. The possible outcomes in each period are assigned probabilities. These outcomes and probabilities are shown on a flowchart that resembles three branches, hence the name of the approach. The results are then aggregated over time to calculate the expected value of each option for the project. The option with the highest expected value is usually considered the preferred choice.

4.4.3 **Sensitivity Analysis**

4.4.3.1 **Background**

Sensitivity analysis is the main and most frequent method for analysing uncertainty. It is a method that measures how sensitive the result of an estimation (in cost analysis or in cost benefit analysis) is to a change in one of the variables. As stated by Drummond *et al.* (1998) sensitivity analysis is a conventional economic method allowing for uncertainty in economic analysis. In principle, sensitivity analysis is required for four major reasons:

- Firstly, when no data are available and informed guesses are required. This may be the case for estimates of a new unproved roadway traffic safety device or a medical technology.

- Secondly, when estimates may be available but they may be known to be imprecise. This may be the case for hospital costs where only the average cost per day, or per admission, is known.
- Thirdly, when there may be methodological controversy, or value judgments that may be incorporated in the study. This may be the case for analytic decisions such as the choice of discount rate, whether or not productivity changes should be included, or the source of values for health care preferences.

Finally, where the analyst wishes to explore the generalizeability of study results to other settings. This is often an issue even where the estimates within a given study are known to be precise.

In each of these situations, the analyst may wish to explore how sensitive the results of the study are to the estimates used for the particular variables or the assumptions made. In general, sensitivity analysis involves three steps:

1. Identify the uncertain parameters for which sensitivity analysis is required;
2. Specify the range over which uncertain factors are thought to vary;
3. Calculate study results based on combinations of the best guess and the most conservative and least conservative estimates.

A brief explanation of each of these steps is given below:

4.4.3.2 **Identifying the Uncertain Parameters**

Economists contend that it is difficult to specify firm guidelines for this step. In principle, however, all variables in the analysis are potential candidates for sensitivity analysis (Drummond *et al.*, 1998; Zerbe and Dively, 1994). One approach could be to give the reason why a variable is not to be included. Possible reasons could be that the parameter is known with absolute certainty, or that a preliminary analysis has shown that or that the concerned variable is believed to have minimal impact on the result of the analysis.

In the analysis of RTA costs, parameters such as the discount rate, the rate of inflation and the rate of economic growth, are possible candidates for sensitivity analysis. The analysis may comprehend all other parameters and variables, which might be used in the analysis.

4.4.3.3 **Specifying the plausible range**

One requirement is determining the range of values to test for sensitivity analysis. According to the general principles a plausible range could be determined by the following (Drummond *et al.,* 1998):

1. Reviewing the literature;
2. Consulting expert opinion;
3. Using a specified confidence interval for the results.

The guidance given by Drummond *et al.* (1998) is that, when judging published studies, the user should assess the justifications given in conjunction with the statement authors make about their analysis.

4.4.3.4 **Calculating the results of the analysis**

In principle there are two basic approaches to conduct sensitivity analysis (Drummond *et a,* 1998; Zerbe and Dively, 1994):

1. the variable by variable approach, also known as the *one way analysis*, which treats each variable separately;
2. the scenario approach, also known as *multi way analysis*, which treats variables in groups.

Hereunder is a brief description to each of these methods:

4.4.3.5 **Variable by Variable Approach**

This method treats every individual variable or parameter separately. Generally, it is based on the following steps:

1. All variables have to be listed for the analysis.

2. For each variable, a possible range of values has to be determined. It is usually appropriate to consider three to five values for each variable, unless the range of possible outcomes for that variable is more restricted. For parameters extrapolated by regression analysis, the practice so far is to take the point estimate as the base case (best guess or the most likely) estimate and the upper and lower bounds for optimistic and pessimistic estimates. This approach is suitable when dealing with time series data. It is possible also to determine the optimistic and pessimistic values in terms of a number of standard deviations above or below the mean value, if such information exists for the analysis. Stochastic data require undertaking a

probabilistic sensitivity analysis. This considers the relative likelihood that particular values (e.g. the extremes) will occur. It applies distributions to the specified ranges and samples at random from these distributions to simulate uncertainty, thereby generating an empirical distribution of the cost effectiveness ratio. It is also common to determine the range of values from the experiences of other similar projects.

3. The third step is to calculate the appropriate result (such as the net present value or the benefit cost ratio) using each possible value of the variable, holding all other values at their expected values.

The approach can best be illustrated by the following example given by Zerbe and Dively (1994): If a calculation involves three variables labelled A, B and C, the analysis would begin by listing the variables and developing optimistic, pessimistic and expected values for each variable. The table would be like this:

Variable	Optimistic	Expected	Pessimistic
A	15	20	30
B	1000	500	200
C	14	13	11

Note that optimistic values are higher for benefits (B & C) and lower for costs (A), since we hope that costs are lower than our best estimate. The reverse pattern holds true for pessimistic values.

Once the values of the variables are established, the usual calculation of net present value (NPV), for example, would be made using the expected values for each of the variables. A sensitivity analysis then requires several additional calculations. First, the NPV is calculated using the optimistic estimate for variable A and the expected values of variables B and C. The calculation is then repeated using the pessimistic value of variable A and the expected values of other variables. These results will show how sensitive the NPV is to changes in variable A. The entire process is then repeated using the alternative values of variable B and the expected values of variables A and C, and the process is repeated again using the range of value estimates for variable C along with the expected values of variables A and B. The final result illustrates the sensitivity of the NPV to changes in each of the variables.

4.4.3.6 **The Scenario Approach**

The preceding approach is useful for conducting relatively simple analyses where the variables can be assumed to operate independently. In the real world, variables are always interdependent. Instead of investigating variables independently, the scenario approach uses several consistent combinations of variables for three scenarios of optimistic, pessimistic and expected values Zerbe and Dively, 1994). These combinations are known as scenarios. This type of sensitivity analysis involves two steps:

1. Identify several possible consistent combinations of variables;
2. Compute the result such as the NPV for each scenario.

The analyst can then see which scenarios are likely to produce favourable or unfavourable results and can make decisions about the project accordingly.

4.4.4 **The Treatment of the Value of Human Life**

4.4.4.1 **Philosophical Background**

Placing value on human life and health outcomes has been a subject of intense controversy for many years. However, different viewpoints exist. On the one side is the moralists' viewpoint which completely disagrees with any approach placing value on human life (Zerbe and Dively, 1994); and on the other side is the economists' viewpoint – the cold-blooded viewpoint – (in Mooney's words), which contends that 'determining the value of human life is no different from determining the value of any other good or service' (Mooney, 1992). The moralists argue that it is inappropriate and unethical to discuss lives using the language of material values. According to them, lives should be discussed using the language of rights and justice (Zerbe and Dively, 1994). In contrast, the economists' viewpoint alleges that people do implicitly, and sometimes explicitly, place monetary values on their lives most of the time. Examples are peoples' expenditure on safety and their risk-free preferences, which are frequently taken by economists as a clue for values that people implicitly place on life (Drummond *et al.*, 1998). Likewise, peoples' investments on pollution control, public health and traffic engineering are other examples of policy measures trading-off between higher costs and more safety, or decisions that require data on the value of life.

Therefore, whether moralistic, ethical or not, the fact is that under the existing laws and regulations, we should accept that people, government agencies, companies and individuals do actually evaluate and place monetary value on life. This might be done implicitly, when taking decisions concerning allocation of resources, among other choices, to promote and prolong life such as decisions concerning public health, injury control, family planning, occupational health, quality control standards and alike. Or, it might be done explicitly, when considering compensation for lives wrongfully lost.

However, Zerbe and Dively (1994) suggest to take note of the following four philosophical issues related to the assignment of values to lives:

4.4.4.2 **Purpose**

The first philosophical issue is that the purpose for which the evaluation of life is made is an important determinant for the evaluation approach itself. A number of examples, given by Zerbe and Dively (1994), can illustrate this. In wars, for example, the value of soldiers' lives to the generals seems to be the opportunity cost of other uses of their lives to win the war. For compensation purposes lives may be valued *ex post* (after the fact). For the purposes of preventing death and injury, lives may be valued *ex ante* (before the fact). These contrasting examples illustrate how valuing lives doesn't lend itself to a simple direct approach that applies at all circumstances. Instead, one needs to clarify the purpose of the valuation before commissioning a certain valuation approach.

4.4.4.3 **Compensation**

The second philosophical issue is that refusing to place a value of life cannot reasonably be thought to apply to the provision of compensation for lives wrongfully lost (Zerbe and Dively, 1994). Compensation for lives wrongfully lost is widespread nowadays among most of the societies in the world. This dates back to the ancient societies and civilisations. In the ancient and present Muslim societies, *Diyatt*e (a predetermined amount of money) is paid by the family of the guilty person to the family of the injured or killed victim. In ancient and medieval English societies, the guilty party pays an amount of money (called Wergild in Old English) to the family of the diseased or injured victim as well. A similar mechanism of compensation is evident in the Babylonian Code of Hammurabi as well as in the Civil Laws of many contemporary societies (Zerbe and Dively, 1994).

Therefore, it is imperative to note that indemnification of lives wrongfully lost is justified in most of the societies, not on the basis whether it is ethical or not, but on the basis that compensation promotes more care.

4.4.4.4 **Discounting Future Lives**

The debate over placing value on human lives leads to the question as to whether human lives should be discounted or not? Many researchers from other disciplines have held that it is immoral to subject human lives for discounting. For example Cropper and Porteny (1990) showed that the lives of future generations as well as the lives of existing generations should be discounted. The assumptions under which these conclusions were made were that: (1) individuals are willing to trade off increases in mortality risks for money; (2) there are alternative uses for life-saving resources; and (3) capital investments yield a positive rate of return. Under these assumptions, a value figure for the human life lost or gained could always be determined by estimating the implicit value people place on their lives when taking decisions averting or accepting risk. These so called willingness to pay (WTP) values could legitimately be subjected for discounting to estimate the present value of human life.

In general, the economists' point of view is that discounting future lives is essential in order to estimate how best funds could be invested among alternative safety measures aiming to reduce fatalities and injuries from RTAs for example. Horowitz and Carson (1990) have shown in their study that people do in fact discount future lives in their decisions. The authors were able to reject the hypothesis that discount rates for saving lives are zero or non-existent and generally were not able to reject the hypothesis that these rates were the same as market rates. Another study, by Moore and Viscusi (1990), showed that workers do discount future health risks and that the estimated discount rates "do not deviate substantially from financial market rates". From empirical studies, the National Highway Transport Safety Administration of the US (NHTSA) suggests a discount rate of 4% for use in discounting future lives. In a recent study, Moore and Viscusi (1994) suggest a discount rate of 5%. The National Health Service of the UK (NHS) suggests a discount rate of 5% as well (Blincoe and Faigin, 1994).

Therefore despite the moralists concerns, it could fairly be concluded that the idea of discounting future lives is sound and is gaining a wide acceptance every day, apparently for very practical reasons.

4.4.4.5 **Quality of Life**

The final issue relating to the philosophical underpinnings of valuing human life involves the question of quality of life. It is apparent that serious philosophical issues can be raised if the analysis focuses only on the number of lives saved, for example through this or that safety measure and not on the quality of life saved. Such an approach will definitely fail to differentiate between savings for a short time a life in pain, such as saving a hospitalised injured person for one week, and a longer-term saving of an apparently higher quality of life. Another example is that, if the analysis is improved by focusing on the number of life-days saved per individual life saved, a distinction could be made between saving a life for a shorter term and a longer term, but quality considerations will still be ignored.

4.4.4.6 **The Economists' Approach**

Thus, it is apparent that the issue of assigning monetary value to lives is a complex problem. According to Zerbe and Dively (1994) the moral issues involved can never be resolved to the satisfaction of everybody (Zerbe and Dively, 1994). Economists and policy analysts have chosen to take a viewpoint addressing these issues by comparing the *value of risk* to other values in a way that reflects the willingness of society to pay or to accept. Through collating the Willingness to Pay (WTP) values implied by peoples' preferences for risk and safety, economists were able to make estimates for the value of life lost or impaired, as will be explained when discussing the empirical applications of this concept in the next chapter.

4.5 **Summary**

To assist carrying out an adequate evaluation in health care and safety fields economists recommend a number of techniques that help improving the analysis. These include the use of shadow pricing, financial analysis to discount future costs and benefits to the present value and to adjust these rates for the effects of inflation, natural economic growth and taxation. That is in addition to the use of sensitivity analysis to incorporate the effects of uncertainty in the analysis.

There is general agreement among economists that the appropriate rate to use for discounting forgone consumption, as the case with RTA losses, is the social rate of time preference (SRTP) which is commonly considered to equate the after tax rate of interest. The argument is that if the productivity that is forgone due to RTA fatalities and the medication and rehabilitation costs that are used to restore injured victims back to their pre-crash status were invested rather than consumed would have earned interest returns. Accordingly, most economists used inflation adjusted real after tax interest rates on various bonds, treasury bills and common stocks as proxy for SRTP. Additionally, a number of conventions exist for selecting the appropriate discounting rate, including governmental announced rates for public sector projects, and the guideline conventions for economic evaluations published by some leading journals. To adjust for the effects of inflation and economic growth in the future estimates economists recommend the importance of examining those rates for a long period of time.

Sensitivity analysis allows for testing the results of the analysis for possible changes in each variable and also for testing the assumptions made about these variables. Due to the common deterministic nature of the data available for RTA evaluations economists recommend the use of sensitivity analysis to account for uncertainty. Thus, most of the parameters used in RTA evaluations are ultimately possible candidates for sensitivity analysis.

Economists are in general agreement that future lives should be discounted in order to estimate how best funds could be invested among alternative safety measures aiming to reduce injuries and fatalities. Through analysing the values implied by peoples' preferences for risk and safety, economists were able to infer the value of life lost or impaired.

CHAPTER 5
USE AND APPLICATION OF THE COST BENEFIT ANALYSIS IN RTA EVALUATIONS

CHAPTER 5

USE AND APPLICATION OF THE CBA APPROACH IN RTA COST EVALUATIONS

5.1 General Introduction

It is established nowadays that RTA economic costs include tangible and intangible costs to individuals and societies. Tangible costs are those measurable in monetary terms and which can easily be assigned to individuals or the society as a whole, whereas intangible costs are those immeasurable in monetary terms. Direct tangible costs include property damage, emergency treatment, the entire range of medical and ancillary costs, insurance administrative costs, police and legal costs, and employer/workplace costs. Indirect tangible costs include productivity costs in the workplace due to temporary and permanent disability, traffic delay, and decreases in home production from these disabilities. Intangible costs include personal emotional consequences, like pain grief and suffering (PGS), which occur to the individual following an accident and which cannot be measured by any conceivable monetary measure.

Although RTA cost elements are easy to identify and categorise, the evaluation of them is not an equally easy matter, as it might be imagined; where the solution can be found by using one or more of simple arithmetic techniques and where a final answer to the problem always exists. Instead, accident cost evaluation is rather a complicated process, involving numerous unknown variables and complicated details, which cannot be traced easily. The difficulty stems partially from the nature and diversity of the consequences of RTA events on one hand, and on the other hand the availability, reliability and precision of data, including the details of the cost items, the classification of accidents severity scales and the discount rates applicable for calculating the present value of future expenditures.

As pointed out by Miller (1994) and other economists, RTA economic costs reflect only one aspect of the RTA problem, i.e. their direct and indirect monetary costs. Nevertheless, RTA victims often suffer physical pain and mental and emotional base describing the full range of trauma sustained by the victims, the severity level of their injuries, the number and percentage requiring medical treatment and hospitalisation, their average initial hospital stay, and the full spectrum of lifetime care and treatment costs for them, etc., which are not available from any current data source in most countries in the world. Missing categories of cost for the different types of injuries include, as reported by Blincoe and Faigin (1992), 'the cost of supported and independent living environments, day treatment programmes, behaviour modification programmes, the full range of outpatient treatment and rehabilitation costs, and some of the costs needed to modify living environment to suit the victims'. Other examples of missing categories of costs for RTA injuries, as reported by Elvik (1994), include some of the costs experienced by others, or the so called RTA external liabilities, including families, friends and employers due to the occurrence of RTAs. That is in addition to the various intangible elements of RTAs: PGS cost, for example, cannot be estimated and quantified reliably from any data source. In view of these difficulties, most analysts opted to use sampling data and computational frameworks to complement these missing categories.

Another problem facing economists evaluating RTA cost elements is the selection of a discount rate to adjust for future losses and costs of RTAs.

In conclusion, however, despite the difficulties pointed out, interest and research on RTA cost evaluation have grown up rapidly in recent years. Researchers, from both economics and public health disciplines have succeeded in developing frameworks to evaluate RTA consequences. In the following sections a review shall be made for the literature that attempted to place value on the consequences of roadway traffic accidents. First, an account of the current approaches of evaluation of roadway traffic accidents will be given. This will include describing in details the CBA based methodological applications attempting to evaluate human life, particularly those evaluating the economic impact of RTA consequences: the Human Capital (HC) approach, the Willingness to Pay Value (WTP) approach and the Comprehensive approach. Second, a summary review for the empirical applications of these methods will be made followed by a conclusion.

5.2 **Current Methods of RTA Cost Evaluation**

The first estimates of road traffic accidents were made in the 1950s in the United States and the United Kingdom (Elvik, 1995). Since then and especially during the 1980s, several studies attempting to quantify the costs of RTAs have been carried out in the major industrialised countries. As a consequence, the literature on RTA costing has grown up significantly.

Generally, the cost categories associated with RTAs are well established. According to most researchers, the value of human life lost/impaired can be argued to consist of two parts in a computational framework. The first part is commonly termed, in economic literature, the pure human cost (PHC) and comprises the monetary value of pain grief and suffering (PGS) that arises when a person is killed/injured. The second part which comprises the monetary value of material damage (MMD) consists mainly of: (i) medical and ancillary care; (ii) emergency services; (iii) lost productivity (lost wages and household production); (iv) workplace disruption; (v) insurance administration; (vi) legal proceedings and police administration; (vii) property damage; and (viii) travel delay on the roadway. These two categories of RTA costs are collectively called, by most economists, the comprehensive costs of RTA (Miller, 1989, 1993; Blincoe and Faigin, 1994).

When the value of PGS, which includes decreases in emotional well-being and increases in pain and suffering or permanent losses in functional capacity is omitted, the remaining costs form the monetary or economic costs of RTA. The approach to determine these costs differs largely among researchers. Hills and Jones-Lee (1994) and other economists summarised the following six approaches:

1. The "Gross Output Approach" also known as the Human Capital approach (HC), approximates the value of human life lost or impaired on the basis of productivity lost at workplace and home. The approach adds the value of medication and property damage to the loss in earnings to estimate the mean cost of RTA injuries.

2. The "Net Output Approach": another version of HC approach in which the present value of the victims' future consumption is subtracted from the gross output figure as calculated from the gross output method.

3. The "Court Award Approach": here, the awards decided by courts to injured victims or their dependants are considered indicative of the cost that the society incurs due to the accidents. According to the approach, other damages due to the accident are also included, such as property damages, medication and police administration.

4. The "Life Insurance Approach": here the costs of an accident are treated as the sum of real damages in addition to the amount that people are willing to pay to insure their lives.

5. The "Implicit Public Sector Valuation Method" is based on the costs and values that are implicitly placed on accident prevention through investments or expenditure on health care and safety.

6. The "Willingness to Pay or Value of Risk Change Approach" deals with the aggregate amount the society is willing to pay for the reduction of risk. These amounts of risk reduction are then interrelated to evaluate the accident costs.

It is established that those approaches produce different estimates for RTA costs. For example, a recent EC funded study, (Elvik, 1995) investigating the costs of RTA fatalities in 20 motorised countries, revealed that cost estimates per fatality varied between 0.87 million Norwegian Kroner in Netherlands to 17.80 million Kroner in Switzerland (corresponding to around 120,000 US dollars and 2.5 million US dollars respectively at May 1994 rate); that variation was mainly due to the different valuation methods applied in each of these countries (Elvik, 1995). Those methods varied from the HC approach (65% of the studies investigated) to the WTP approach. The study revealed that, in countries where the value of lost quality of life was estimated (WTP value approach), the mean cost of a fatal accident was more than twice as high as in countries where lost quality of life was not included in the evaluation i.e. applying HC approach only. In countries relying on the WTP approach, the mean cost of a fatal accident was around 11 million kroner, while in countries relying on HC approach the mean cost of a fatal accident was 5.69 million kroner only. This disagreement apparently reflects the importance of the method selected in the determination of RTA costs. It is generally agreed that the estimations derived by HC approach reflect only the pure monetary value of crash damages and injuries sustained in RTAs whereas the WTP value estimations reflect the PGS costs also.

Elvik (1995) referred the differences in the evaluation methods to historical evolution. According to him, the conceptual framework of accident evaluation, like other areas of knowledge, went through historical evolution. He argued that, over the last 40 years the estimation of RTA costs went through four phases over which the estimated costs increased enormously. These increases, he stated: "were not just a result of generally rising prices in societies but rather a result of periodic revision of the valuation methods" (Elvik, 1995). According to his study, the first phase lasted from 1950s until the 1960s, during which costs were based on the net loss of output approach and no allowance was made for lost quality of life. The second phase lasted from 1960s to 1970s when economic valuations of RTAs were based in most cases on the gross loss of output approach in which the consumption of the accident victim was no longer subtracted from the value of lost production. In the third phase, covering the period from 1970s until the 1980s, an arbitrary value for PGS was added to the gross value of lost output in a number of countries. This value was meant to capture the 'human costs', i.e. (lost quality of life) of RTA victims. In the fourth phase starting in the late 1980s, researchers in some countries have explicitly added estimates of the value of quality of life based on the WTP approach.

Elvik (1995) added some other historical reasons for the upgrading trend of RTA economic evaluations through pointing out that motorised countries experienced substantial growth levels in income since the 1950s, which enabled them to afford increasingly expensive safety targets. An additional reason he contends is that competition for public funds has become more intense. 'Some motorised countries have run up huge public budget deficits, forcing them to cut spending. Raising the economic valuation of RTAs would make safety projects more competitive and less vulnerable to spending cuts' (Elvik, 1995). He concluded that not all countries have gone through all of the phases described above, but some of the motorised countries, including Great Britain, Sweden, and the US, must have gone through all or at least most of these phases. Although he did not consider two approaches enlisted by Jones-Lee, namely the Court Award approach and the Life Insurance approach, his count appeared reasonable and on-line with most of the studies, which attempted to clarify the differences in the approaches applied to the evaluation of RTA costs.

However, agreement is unanimous nowadays about three, CBA based approaches: (a) the Human Capital approach (HC) which quantifies the direct and indirect RTA costs to the individual and society, but ignores the quality of life lost, (b) "the revealed preference approach" or the WTP which attempts to place values on suffering and bereavement as well as quality of life lost for injured victims; (c) the comprehensive approach, which attempts to combine the value figures of the HC approach together with those produced by the WTP approach to estimate the global cost of RTAs, including lost quality of life due to RTAs. In the following section each of these approaches will be considered in details.

5.2.1 The Human Capital Approach

5.2.1.1 Introduction

According to Blincoe *et al.* (1992), Elvik (1994), and Haight (1994), the conceptual framework of the HC approach involves placing a monetary value on the tangible health consequences - direct and indirect costs - to individuals and society from decreases in the health status of individuals injured in RTAs (Blincoe and Faigin, 1994). Individuals are viewed as elements in the societal production process, and their death or incapacitation is valued in terms of estimated future losses to this process, sometimes minus their estimated future consumption. Or, as elaborated by Drummond *et al.* (1998), the HC approach treats an injured individual as an investment in a person's human capital. As such, the resources consumed in response to an injury or a fatality, that might otherwise have been invested, can be regarded as a forgone investment. In measuring the *payback* on this investment the value of the healthy time produced can be quantified in terms of the person's renewed or increased production in the market place (Drummond *et al.*, 1998). Zerbe and Dively (1994) call the approach "the Foregone Earnings approach" (Zerbe and Dively, 1994). The approach considers the individual's value of life as flowing from one's lifetime consumption. That is, the value of life is approximately what one will add to the national product discounted to present value.

Hence, it can be argued that the HC approach is a production based method for valuing decreases or increases in health status through placing monetary values on healthy time using market wage rates and the total cost of the health consequence itself. The approach attempts to place value on the tangible, direct and indirect consequences of health events, rather than their intangible consequences, such as pain grief and suffering. For instance, according to the HC approach, the tangible costs for RTA victims include the direct cost elements for victims and their families including emergency medical care, initial medical costs, rehabilitation costs, long-term treatment expenses, insurance administrative expenses, administrative and legal costs and employer/workplace costs. Indirect cost elements include productivity losses at work place due to temporary or permanent disability and decreases in production in the home resulting from disabilities. RTA costs other than those directly attributable to an injury - property damage and travel delay - are usually added to the cost of injury and non-injury crashes.

The approach ignores the intangible cost elements of injuries such as decreases in emotional well-being unless they result in medical treatment, and it also excludes increases in pain and suffering and permanent losses in functional capacity unless they result in permanent earnings losses (Blincoe and Faigin, 1994). Additionally, this approach does not attempt to measure decreases in quality of life.

An operational illustration for the approach, in determining the total costs attributable to RTAs, is given by Andreassend (1985). He first, quantifies the outcomes of accidents per casualty injury class. This consists of determining the unit, direct and indirect costs of each person-casualty class, then multiplying the mean of these costs by the total number of persons in each class, then summing the products and finally adding the cost of repairing motor-vehicles for all accidents (injury and non-injury, reported and unreported).

Another illustration for the approach is given by Schoenbaum *et al.* (1976) in their evaluation for the rubella vaccination. Their study examined the costs and consequences of Rubella vaccination. The consequences were identified as those costs that would be avoided as a result of the vaccination programme. The avoided consequences included not only the averted medical costs associated with the acute rubella and congenital rubella syndrome, but also the reduced economic productivity that results from disability and premature death. In order to place a monetary value on the reduced productivity, the authors computed the average life time earnings and estimated the amount of earnings that would be lost if no rubella vaccination programme were in effect. They found that the costs of the programme totalled \$28,937,400 and the value of the lost productivity totalled \$9,521,200 for both medical conditions (Schoenbaum *et al.*, 1976).

One of the earliest evaluations using the HC approach is the work of Rice in the US (1967) who, using mainly loss of productivity, found a figure of less than \$60,000 per fatality. A more recent estimate (Miller *et al.*, 1989) using six categories of cost (property damage, medical costs, loss of productivity, emergency services, legal and court estimates and other administrative costs) in a model aggregating costs of injuries to each person in the crash according to the injury severity level, based on the distribution of injuries in a typical crash, gave a total estimate for injury and crash cost in the US in 1988 of more than \$34 billion. The average cost per fatality amounted to \$425,406, of which 90 percent was contributed by loss of productivity. The average cost of a maximum abbreviated injury scale (AIS) of 5 was estimated to cost \$390,000, almost as large as the cost of a fatality, and an AIS-4 injury was found to cost \$155,000. Medical costs comprised 40% to 45% and productivity losses about 35% of the total costs for these injury levels. Average costs per injury were much smaller for less severe injuries: \$19,000 for AIS-3, \$8,000 for AIS-2 and less than \$3,000 for AIS-1. Overall, the average cost per non-fatal injury was just under \$6,000. The pattern of cost per crash was found to be similar to the pattern per injury. Fatal crashes cost an average of \$500,000, followed closely by AIS-5 crashes at 450,000. AIS-4 crashes were found to be a third lower at \$160,000. The remaining crashes, on average, were an order of magnitude lower in cost: about \$20,000 for an AIS-3 crash, \$10,000 for AIS-2, and \$4,000 for an AIS-1. Because of the predominance of minor injuries, the average non-fatal injury crash was found to cost only \$8,000.

In Australia, a similar study (Hendrie, Rosman and Harris, 1994) was carried out to quantify the hospital inpatient costs resulting from road crashes in Western Australia, and to investigate factors relating to hospital costs from road crashes. The study was based on data about road crash casualties in Western Australia in 1988. All road crash casualties who were injured severely enough to be hospitalised in Western Australia in 1988 were included in the study. A case-mix classification system was used to classify patients into diagnostic related groups (DRG). Hospital costs were assigned to individual patients on the basis of their DRG and length of hospital stay. For each road crash casualty, the cost of hospital inpatient care was estimated by multiplying the length of stay in hospital by the appropriate bed-day cost for 1988-89, based on DRG and hospital. Several factors affecting hospital costs, such as type of hospital, body region of injury, injury severity, age, sex, road user type and number of injuries, were examined.

Hospital discharge data were obtained from the Hospital Morbidity System (HMS) of Western Australia. Casualties were identified using the International ICD9-CM classification. Based on the HMS data, road traffic casualties were allocated DRGs using a DRG grouper programme. This programme first assigns a patient to a major diagnostic category based on the principal diagnosis and then it allocates the patient to a procedure category depending on whether or not an operating room procedure was performed. Further divisions into DRGs are then based on a number of data items, including the type of procedure and/or the specific diagnosis, patient age, presence of complications and other clinically relevant information. A cost model was used to estimate hospital inpatient costs according to DRGs. This model distributed only inpatient-related costs among DRGs. The main data for estimating costs were first obtained from the complete records of four teaching hospitals. Due to the absence of data for other hospitals, these estimates were used after adjustment to estimate the inpatient-related costs among DRGs for other hospitals. Hospital inpatient costs were estimated for each road crash casualty by multiplying the number of hospital bed-days by the appropriate DRG cost per bed-day. Road traffic injuries were further classified according to the Abbreviated Injury Severity scale (AIS).

The study estimated the annual cost of hospital treatment for road crash casualties as $13.9 million. There were 4111 casualties admitted to hospitals following injury in a road crash and the mean hospital inpatient cost was $3,373 per casualty. At an average duration of 7.7 days this implied an average bed-day cost of $438. The analysis of the injury data by body region revealed that the most costly type of injury with regard to total hospital inpatient costs were injuries to the lower extremities, which had a mean cost of $6,042 per casualty; these accounted 33% of the estimated costs. Head injuries contributed to 27% of total hospital costs and accounted for more road crash injuries than any other body region. Injuries to all other four body regions each accounted for 8% to 11% of costs.

Cost variations also existed within injury severity levels. For minor injuries (AIS 1 or 2), the mean cost varied from $3,825 for injuries to lower extremities to $1,388 for spinal injuries. Lower extremity costs were also the most costly ($9,387) for those sustaining injuries of moderate (AIS 3) severity, followed by head injuries with a mean cost of $7,312. There was a considerable variation on the costs of severe (AIS 4 or 5) injuries: severe injuries to the spine averaged $33,424 while the mean cost of severe injuries to the head was $16,580, and to the trunk it was $8,359.

A study estimating the external costs of RTA injury in Norway (Elvik, 1994), defining external costs to include all costs that are imposed on others and not borne by the person whose activity generated the cost, identified three types of external costs: system externalities, physical injury externalities and traffic volume externalities. System injury externalities were costs that road users imposed on the rest of the society. Physical injury externalities were costs that one group of road users imposed upon another in crashes in which both groups were involved. Traffic volume externalities were costs imposed on other road users when an additional road user joined the traffic system. Based on a detailed breakdown of the costs of traffic injury, the study revealed that system externality costs constituted about 30% of the estimated total cost of traffic injury. Physical injury externalities were estimated to contribute to about 10% of the total cost of traffic accidents. No precise estimate was found for traffic volume externalities. The study confirmed that the sum of the system externality and the physical externality was about 0.25 Norwegian kroner per kilometre of driving. That was taken as the average external cost of traffic injury in Norway.

The relationship between traffic volume and the number of injuries was not known in sufficient detail to determine whether the marginal external costs of traffic injury were equal to the average external costs. For the system externality the average external costs appear to be a good approximation to the marginal external costs. For the physical externally, the marginal external costs were not known due to insufficient data describing the relationship between the number of injuries in crashes involving a pair of road users from different groups and the intersecting traffic volume of the two groups.

The study discussed the possibilities of internalising the external costs of road traffic accidents by means of insurance or public tax schemes. It revealed that, in Norway, the current tax rates on ownership and use of motor vehicles cover the external costs of traffic injury as well as other external costs of driving, although the tax system was not designed explicitly for this purpose.

A study reviewing frameworks for accident evaluations in Australia (Andreassend, 1985) reviewed and discussed the various methods used for calculating the costs of road traffic accidents there. It revealed that the HC approach is most dominant in estimating the costs of accidents. To derive the correct costs of accidents of various severity levels, using the HC approach, the study suggests the use of unit costs per person-casualty class that requires knowledge of all the casualties of various classes within a specific severity level. The study argues that using coarse severity levels, such as fatal, injury and damage, only produces biased results due to the high skewed distributions of costs which makes the mean cost for each level meaningless. The study addressed the question of constructing a method for estimating costs of road traffic accidents and accident types and illustrated the framework for applying unit casualty class costs and unit accident type damage repair costs to accidents of various accident types and severity levels. It concluded that such an approach requires detailed data, specified by injury severity scale for every person involved in traffic accidents, or otherwise costs are underestimated.

In Jordan, a study evaluating the economic impact of RTAs in Jordan used the HC approach (Jadaan, 1993). The cost of fatalities was estimated by using the average age of the deceased victims and subtracting it from the average age of retirement. The total number of years for which productivity was lost was then multiplied by the average wage rates for Jordan. The total was then discounted the present value by using a discounting rate of 10%. Pain, grief and suffering (PGS) values were ignored and the cost of material damage was obtained from insurance companies. The cost of medical treatment was obtained through a sample survey based on hospitals, while the average stay in hospitals was obtained from the records. The estimated cost, for all RTAs in Jordan for 1981, amounted to a total of JD 11 million.

A recent study, using the HC approach (Glodstein *et al.,* 1997) estimated the economic costs of motor vehicle crashes (MVCs) involving teenage drivers in Kentucky, 1994. The data sources were the Kentucky State Police reports, the Kentucky Accident Reporting System and the State Bureau of Census. The Police coding of injury severity at the crash scene was used as a basis for estimating injury severity level among victims. An IBM compatible software, *Crash Cost*, obtained from the National Highways Traffic Safety Administration was used to derive cost estimates. The *Crash Cost* programme uses the HC approach to estimate the economic costs of MVCs. Direct costs included emergency services, initial medical costs, rehabilitation costs, long term care and treatment, insurance administration costs, legal costs, and employer workplace costs. The *Crash Cost* programme uses a 4% discount rate to estimate productivity losses based on the present value of future earnings. Estimates were also derived for costs other than those directly attributable to injury, such as property damage and travel delay. Importantly, *Crash Cost* focuses on the economic impact of MVCs; thus cost estimates do not include values for pain, grief and suffering, nor do they measure decreases in 'quality of life' among MVC victims and their families. Because MVC related injuries are mostly multiple, the unit cost estimates for nonfatal injuries were based on the Maximum Injury Severity scale (MAIS). The programme includes mechanisms for determining incidence when specific state data are not available or when data are not reported.

The study found that teenage drivers had significantly higher rates than did adult drivers. The death rate for 16-19 year old drivers was 43.6 per 100,000 licensed teenaged drivers, and 19.0 per 100,000 for drivers 20 years of age and older. Injury rates were highest for 16 year olds, and decreased with increasing age. On average, fatal injury rates for 16-19 year olds were at least three times higher than those of older drivers. Cost estimates were calculated on a per person/vehicle basis. A single fatal injury was found to cost $642 700. The most costly fatal injury expense category found was productivity (wage work and household work), accounting for 80% of the total costs. Market productivity value lost was discounted at a rate of 4% over the victim's remaining life span. Insurance administration and legal costs accounted for 17% of the costs per fatality. A critical injury was found to cost $563 000. The medical expenses of these injuries were found to account for 45% and productivity losses accounted for 33% of their total unit costs. Other expenses ranged between $5700 (MAIS 1) to $151000 (MAIS 4). In general, unit costs rose with increasing levels of injury severity. Total costs were estimated by multiplying unit costs by the number of fatal, nonfatal and PDO MVCs in which at least one teenage driver was involved. For the total number of fatal injuries, costs exceeded $91 million. For nonfatal injuries and property damage only crashes (PDOs), total costs were $318 million. Overall, the total cost estimate for MVCs involving teenage drivers was nearly $410 million. The study recommended that strategies for prevention of MVCs attributed to teenage drivers should reduce both the numbers and the costs of crash related death injuries.

5.2.1.2 **Merits and Demerits of the Human Capital Approach**

The HC approach has the merit of being reasonably easy to assess, and, as pointed out by numerous economists, it is actuarially sound in using age-specific accounting. Further, the HC approach is used widely to establish awards in wrongful death and injuries cases (Zerbe and Dively). It has the advantage of being subject to fairly objective calculation and as such, it makes sense as a measure of economic losses to survivors. In health care evaluations, economists argue that the costs estimated using the HC approach are estimated in quite similar ways in most industrialised countries (Blincoe *et al.*, 1991; Miller, 1994). For that reason, the approach is commonly held to be valid for comparative evaluation across countries; and also for the following purposes:

1- To calculate economic cost savings from reducing a given number of injuries or crashes;

2- To demonstrate the economic magnitude of the crash problem;

3- To evaluate the impact of injury on a specific sub-sector of the economy, i.e. consumption of medical resources or employer impacts.

However, according to Drummond *et al.* (1998) some measurement difficulties arise from the HC approach. First, although in theory wage rates reflect the marginal productivity of a worker at workplace, there are often imperfections in labour markets and wage rates may reflect *inter alia*, inequalities such as discrimination by race or gender. Therefore, it is doubtful that these rates would represent a reasonable estimate to use for marginal productivity of labour. Second, if the study is from a societal point of view, the analyst will need to consider the value of healthy time gained that is not sold for a wage. This raises the problem of placing shadow prices on non-marketed resources. For example, suppose a homemaker receives some treatment and is now able to return to his or her duties looking after the children, whereas previously he or she could not. To measure the loss in home work due to his/her absence for treatment two methods attaching shadow prices exist. The first is *an opportunity cost of time* approach, which argues that the value of such production at the home should at least be valued at a rate as great as what could be earned in the labour market, or otherwise the homemaker would choose to enter the labour market. Hence, the time would be valued according to the wage-rate forgone. A second approach, known as the *replacement cost* approach, attempts to quantify how much it would cost to replace the homemaker in the home with the services from the market (e.g. gardening, cleaning, child minding, etc.). Both of these approaches have been used to value households' time in studies. Examples can be found in the works of Miller *et al.* (1994), Blincoe *et al.* (1995) and Goldstein *et al.* (1997).

In addition to the difficulties of the practical measurement problems mentioned, there are some other methodological and technical problems. Firstly, estimates based on the HC approach are usually made on the basis of the expected lifetime earnings of the individual, i.e. the retirement age. The implication is that the productivity estimates of those of the elderly, or those otherwise unproductive, may be given a negative value if their consumption is expected to exceed their contribution into production. Secondly, a technical difficulty with the HC approach is the choice of discounting rate to obtain present values. Although that is a general problem with any forecasting and is usually avoided by using sensitivity analysis, according to Haight (1994), the choice of a suitable rate is especially sensitive in RTA fatalities and injuries because the age distribution of injuries is usually skewed towards youth, with corresponding longer life expectancies. Thirdly, as mentioned earlier in this section, the injury and crash costs calculated using HC approach do not include decreases in emotional well-being unless they result in medical treatment, nor do they include increases in pain, suffering or permanent losses in functional capacity unless they result in earnings losses. This implies that estimates measured using the HC approach systematically fail to encompass the far-reaching consequences of the health events in general, including those of RTAs; i.e. they fail to measure decreases in the quality of life. Fourthly, these estimates, according to Miller *et al.* (1994), deliberately exclude payments from public assistance, unemployment insurance, worker's compensation, private insurance, and other sources. The said payments do not increase the cost of injuries. Instead, they transfer part of the burden of injury from the injured and their families to the society. Accordingly, they should be included as an external cost of injury to the society rather than being neglected altogether.

Due to the omissions mentioned in addition to the practical measurement problems outlined in the previous section, the HC approach came under attack by various economists who argued that the injury and crash costs quantified using the approach are not comprehensive for cost-benefit analysis. They argued that the injury and crash costs calculated using the HC approach, although including all the direct and indirect cost items of RTAs, systematically ignored "the quality of life lost" for diseased and permanently disabled victims. They did not reflect, fully, decreases in emotional well-being or as it is better known the quality of life, nor did they include increases in pain and suffering or permanent losses in functional capacity (Miller, 1994; Blincoe and Faigin, 1991). Therefore, according to most economists, the monetary values of RTAs produced by the HC approach should not be used as a direct estimate for the costs of reducing injury and crashes in the derivation of benefit- cost ratios (Schelling, 1968; Mishan, 1971; Baiely 1980; Gillete and Hopkins 1988; Jones-Lee 1982; Menzedl 1986; National safety Council 1991; Thompson 1980; and

NHTSA, 1990). Instead, comprehensive costs, not monetary costs, should be used in benefit cost analysis.

5.2.1.3 **Human Capital and Welfare Economics**

In the late 1960s, economists realised that this production-based approach does not comprehensively measure the consequences of RTA, and therefore, does not provide the appropriate value measures to use for cost benefit analysis. Mishan (1971) contended that the HC approach was not consistent with the foundations and principles of welfare economics because it offered a narrow view of the utility consequences of the evaluated projects, restricted to forgone earnings or impacts on labour productivity. According to him, the more fundamental and relevant notion of value embedded in evaluations based on welfare economics is what consumers who gain from the programme are willing to sacrifice to have the programme in question. It is this collective willingness to pay (i.e. willingness to sacrifice other goods and services) which is the focus of the CBA approach, recognising that not all the consumers will benefit and some will lose and require compensation. According to Drummond *et al.* (1998) Mishan's contribution was to shift the focus of the debate and practical measurement toward contemplating what monetary compensation individuals required for reduced health, or how much they would be willing to pay for improved health.

5.2.2 The Willingness to Pay Value (WTP) Approach

The WTP approach is based on the principles of *Pareto* efficiency in welfare economics (Zerbe and Dively, 1994; Drummond *et al.*, 1998). The basic aim of the new approach is to derive the implied monetary values of safety that reflect the preferences and wishes (willingness) of those members of the public who are at risk from a certain hazard, and who shall be affected by safety investment decisions aiming at reducing the risk associated with that hazard. Thus, under this approach one seeks in principle to determine the maximum amounts that affected individuals would be willing to pay for (typically small) improvements in their own or others' safety. These amounts are then aggregated across all affected individuals to arrive at an overall value for the safety improvement concerned. Such a value could be considered as a clear reflection of what the safety improvement is "worth" in total to individuals in the group concerned. If the small individual safety improvements are such that, in aggregate, they can be expected to prevent precisely one *injury* (individual reductions in the risk of injury of 10^{-5} applying to each of one hundred thousand people), then, as shown by Jones-Lee (1989), aggregate willingness to pay is well approximated by the mean value, over the affected group, of individual *marginal rates of substitution* of wealth for the risk of injury. Such a value is then naturally referred to as the WTP based value of preventing a statistical injury of the particular severity concerned. Using the new approach, the direct economic costs of RTA (lost productivity, property damages and medication costs) can be added to the willingness-to-pay (WTP) values to produce a more comprehensive measure of preventing an injury. The new approach is considered by many economists to be theoretically superior and more consistent with the principles of CBA approach and in line with the current thinking on road safety world-wide (Miller *et al.*, Elvik, 1995; Drummond, 1981, 1998; Zerbe and Dively, 1994).

5.2.2.1 **Current Approaches for Estimating WTP Values**

In principle, the estimation of WTP values can be made either through estimating the affected people's willingness-to-pay (WTP) for additional safety or their willingness-to-accept payment (WTA) for bearing additional risk to life (Zerbe and Dively, 1994). The theory underlying the approach is that assuming a right to life, the value of avoiding incremental risk is the amount that one is willing to pay for additional safety to avoid that incremental risk. On the other hand, the value of accepting an increased risk is the amount that one is willing to accept to undertake that risk. Therefore, the focus of the question contemplated by the approach is what would one pay to avoid an additional risk or what would one accept to take risk? Thus, it is logical to calculate willingness to pay values for perceived benefits and willingness to accept values for perceived losses.

The following example, given by Haight (1994), shows in simple terms how the value of life or reduced and lost quality of life can be found from WTP. Suppose that, in a town with a population of 100,000, each person is willing to pay £25 for a countermeasure, which would reduce the probability of death from 0.0009 to 0.0008. This would mean a reduction in the expected number of fatalities from 90 to 80 at a cost of £2,500,000, or £250,000 per life saved. This calculation (essentially £25/(0.0009 -0.0008) is independent of the size of the town. If people were willing to pay £50 for the same improvement, the value of life would be increased to £500,000.

On the other hand, the willingness to accept (WTA) is best illustrated by the following example given by Zerbe and Dively (1994): Suppose you are willing to accept for \$5 to undertake an additional risk of one in a million chance ($1X10^{-6}$) of fatal injury. For simplicity, suppose all injuries in this activity are fatal. In this case, the value of your life would be 5X1000,000 or \$5,000,000.

It is these sorts of figures that are used to estimate statistically "value of life" calculations. But this \$5,000,000 figure will be very misleading if it used as a single baseline figure for the value of life. As pointed out by Haight (1994), the premium is specific for the initial level of risk and for the added risk assumed. For a larger risk, it is expected that one would require a larger premium per unit of risk. As one takes on greater risks, one's valuation of risk per unit is most likely to increase. This reflects the fact that, for safety as for most goods, the value of additional units of safety falls as one gain more safety.

The resultant values generated by either WTP or WTA are usually aggregated across different individuals, using the suitable statistical method, in order to arrive at a standardised statistical average to prevent one fatality or a fatal injury. Advocates of the approach suggest that WTP studies should concentrate on individuals' health money decisions *under uncertainty* rather than *certainty* (Jones-Lee, 1976). This is due to that fact that under a certainty scenario a person might (quite reasonably) request infinite compensation for, say loss of life which would make the WTP value and hence the CBA analysis intractable. That aggregate is naturally referred to as the value of preventing 'statistical fatality' or the value of life (Jones-Lee, 1994).

According to Miller (1993) and most economists working in this area, three methods are presently in use for estimating the value of life: (1) estimates of wage premiums for accepting risk, (2) observed market behaviour (e.g. voluntary purchases of safety devices), and (3) contingent valuation or interview studies.

5.2.2.2 **Estimates of Revealed Preference Studies**

The use of wage-risk premiums as a measure to accept additional risk is straightforward and follows the logic of the previous examples. The goal implied by these studies is to examine the relationship between particular health risks associated with hazardous job and wage rates that individuals require to accept the job (Drummond *et al.*, 1998). As such, the approach is considered by economists to be consistent with welfare economics frameworks because it is based on individuals' preferences regarding the value of increased (decreased) health risk, such as injury at work, as a trade-off against increased (decreased) income, which represents all other goods and services that an individual might consume (Drummond *et al.*, 1998).

An example, originally made by Zerbe and Dively (1994), can best illustrate the approach. If one accepts a job with a greater than usual risk, say an additional risk of $1X10^{-4}$ of death, and requires a wage premium of \$40 to accept this additional risk, the value is $4X10^{-4}$, or \$400,000 (Zerbe and Dively, 1994). We should then test the statistical representativeness of our risk evaluation to the specified level of risk and the implicit value at other levels of risk.

The strength of the revealed preference approach is that it is based on actual consumer choices involving health versus money, rather than hypothetical scenarios and preference statements. However, Drummond *et al.* (1998) cited two weaknesses with the approach. The first is that the estimated values made using the approach varied widely and they seem to be context or job specific. He argues that the reason rests with the use of observed data, which makes it difficult in the analysis to disentangle the numerous factors that confound the relation between wage and health risk. The second weakness cited by Drummond *et al.* (1998) is that the observed risk-money trade-offs might not reflect the kind of rational choice revealing preferences that economists believe. He argues that many imperfections intervene in labour markets, in addition to limitations in how individuals perceive occupational risks.

Another revealed preference valuation method reported by Drummond *et al.* (1998) is an approach that could well be described as a societal revealed preference; unlike the individual based revealed preference. The approach review the past decisions, such as court awards for injury compensation, to elicit the minimum value that society (or its elected representatives) places on health outcomes, or government decisions on health care expenditure to elicit the monetary value assigned by the society to health outcomes. The critique for the approach is centred on its primary reliance on the assumption that some rational process had truthfully revealed, in the prior decision, societal values for health outcomes that could be generalised in the future analysis, which may not be the case.

5.2.2.3 **Observed Market Behaviour Method**

Just as risk premiums (from wage-risk relationship) can be determined from choice among jobs of differing risk so also risk premiums can be derived from individuals' choices among safety alternatives and different risk bearing levels (Zerbe and Dively, 1994). An example that can illustrate this is the availability of the option of safety airbags on new models of motor vehicles. Although motor vehicles with airbag are significantly expensive compared to those without it, still they witness increased demand, apparently on grounds of increased safety. This additional expenditure to afford vehicles with airbags is evidently a clue about the (risk premiums) individuals are willing to pay to avoid the risk of being killed or injured. Likewise, the values implied by product demand and price in markets for safety related projects like smoke detectors, houses in areas with little air pollution, etc. It is from these kinds of changes that risk premiums can be elicited and determined (Zerbe and Dively, 1994).

One of the best studies, in which observed market behaviour methodology is applied, is the one conducted by Ippolito and Ippolito (1984). They provided an interesting measure of life by looking at the cigarette market. Changes in the information and beliefs about the life expectancy effects of smoking were compared with changes in individuals' demand for cigarettes. Estimates were made as to what the demand would have looked like in 1980 had no disclosures appeared about the hazards of smoking. These estimates were compared with the actual demand for cigarettes in 1980. The reduction of demand was then compared to the change in perceived risks to give a value of life figure. Sensible adjustments were made for the deterioration in cigarette quality and this contribution to the reduced demand was separated from those due to the health disclosures. Ippilito and Ippilito found an average value of life of about $460,000 in 1985 dollars. That is suggesting that, on average, individuals were willing to pay up to $460 to reduce the risk of death by 1/1000 or up to $46 to reduce the risk of death by 1/10,000.

Thus, the approach can be thought of as an attempt to measure values of marketed and non-marketed goods and services such as health care and safety through measuring the underlying consumer demand and preferences to elucidate the implied values people place on such services and goods.

5.2.2.4 **Contingent Valuation Method**

Contingent valuation method (CVM), as the name suggests, refers to survey methods (interview or questionnaire techniques) in which respondents are presented with hypothetical scenarios about the programme or the problem under evaluation (Zerbe and Dively, 1994; Drummond *et al.*, 1998). Respondents are customarily required to think about the contingency of an actual market existing for a programme or health benefit and to reveal the maximum they would be willing to pay for acquiring a benefit or how much they are willing to accept to bear a loss? In a contingent valuation study, interviews or questionnaires and sometimes, experimental techniques, which elicit subjects' responses to the setting, can be used to determine answers to valuation questions. The idea is to elucidate from people's responses bids (answers) that reveal what amount they will be willing to pay for a benefit or to accept to bear as a loss. It is the aggregation of these bids which can be large or small, across individuals which forms the basis of CBAs based on CVM method.

An example, originally given by Jones-Lee (1985) and reported by Drummond (1998) that illustrates the approach can be summarised here. Suppose that one is buying a particular make of car. One can, if he/she wants, choose to have a safety feature fitted in the car at an extra cost. To elucidate the value of life implied by this protective act the approach would ask about how much the individual will be prepared to pay for that extra device, bearing in mind his/her ability to pay. If the device is known to reduce the probability of death by half from 10/100,000 to 5/100,000 for example, and if the maximum premium that he/she is willing to pay for that reduction in risk is $50, the implied value of his/her life will worth $50/5 x 10^{-5}$ which will equal $1000,000 (Drummond, *et al.*, 1998).

The CVM approach has become popular and important because it has the potential to generate value estimates for non-marketed goods and services, such as reduced pain and suffering, that may not be obtainable in other ways. However, it is important to highlight the fact that the extent that the CVM results are reasonably reliable and of reasonable quality is an empirical question whose answer will depend in part on the techniques used to collect the data. According to Drummond *et al.* (1998) those techniques differ between studies. Reviews by economists of contingent WTP studies in health care revealed wide variation in what questions are being asked, of whom, and how (O'Brien and Gafni, 1996). For example, it appeared in many studies that respondents were unable to assess the risk, either before or after the counter measure was implemented or to state exactly the amount he/she would be willing to pay to reduce risk by a given percentage. Economists found that for questions referring to their own risk, people, in some cases responded that they would be willing to pay any amount of money to stay alive. As suggested by Jones-Lee (1994) these types of persons will tend to inflate the average value. However, to resolve such problem Jones-Lee (1994) suggests to use the median rather than the mean in approximating the CVM value figures if there are obvious serious doubts about the presence of such extreme responses.

An empirical illustration for the approach is best made by reviewing a study applying the CVM approach, carried out by Jones-Lee *et al.* (1994), to estimate the WTP values of safety investments to the London Underground Limited (LUL). The aim of the project was to measure, in monetary terms, the value of the benefits of safety interventions in the LUL and to weight that against the costs of those interventions to reach an informed decision as to whether or not any particular underground safety project be undertaken. The set of value improvements considered for estimation included interests of well being of members of the travelling public who shall benefit from the lower causality rates as well as the reduced road congestion and pollution that will result from a substitution of an underground for road use. The study was undertaken in three phases, phase (0) identified the key issues and questions to be addressed; phase (1) involved a pilot study to evaluate the feasibility of the proposed estimation procedure and the order of magnitude of the WTP values of underground safety; and; phase (2), involved a large scale sample survey. The method adopted was to establish the amounts that affected individuals would be willing to pay for typically very small improvements in their own or others' safety. These amounts were then aggregated across all potentially affected individuals to arrive at an overall monetary value for the safety improvement concerned. The study estimated a WTP value of £1.7 million in 1991 prices for preventing one statistical fatality. The resultant aggregated WTP was used to reflect the value of preventing a fatality or the "value of life", or in other words, to represent the overall value of safety.

5.2.2.5 **Summary**

The willingness to pay approach has become widely accepted by economists working in this area, for evaluating the value/cost of human life lost/impaired, and the monetary value of pain, grief and suffering associated with accidents. According to Scodari and Fisher (1988), almost every U.S. regulatory analysis monetising life saving benefits has used willingness to pay values since 1986. In UK, the approach has been introduced and applied by the Department of Transport since 1988 to value the prevention of fatal casualties. It replaced the method used since 1968, which was based on loss of output, medical costs and an estimate for PGS costs (Oreilly, *et al.*, 1994). Many other industrialised countries have already opted to use WTP or WTA methodology in quantifying the effects of RTA including Japan, Denmark and Norway.

It could be concluded that using the WTP/WTA values helps in generating estimates that are more superior and more consistent with the principles of CBA approach.

5.2.3 Comprehensive Values of RTA Prevention

The use of comprehensive costs, alternatively called 'rational safety investment levels', was first suggested and introduced by Miller (1989). The approach measures and values risk reduction by examining what people would pay to reduce risks (Miller 1993) through adding up the WTP value of lost quality of life to the monetary costs of RTA quantified by the HC approach. As such the approach combines the results of both the HC and the WTP to estimate the comprehensive costs of RTA outcomes. Accordingly, the following RTA cost components are added together to derive the comprehensive RTA cost figures: (i) medical and ancillary care; (ii) emergency services; (iii) lost wages and household production; (iv) workplace disruption; (v) insurance administration; (vi) legal proceedings; (vii) property damage; (viii) travel delay; and (ix) lost quality of life. When the quality of life is omitted the remaining cost items are considered by the approach monetary costs. Miller argues that comprehensive costs are much more valid to use in benefit cost analysis compared to the HC monetary costs. He argues that the value figures produced by the latter approach underestimate the elderly, women and minorities (Miller, 1993). Additionally, he argues that using such monetary costs in the analysis of safety decision would inappropriately favour mobility over safety by undervaluing the improvements in quality of life arising from safety measures.

The approach is gaining recognition, worldwide. Among the recent applications of the comprehensive approach was a study carried out by the US National Highway Traffic Safety Administration (NHTSA). The study estimated the total cost of RTAs, which occurred in 1990, to exceed \$137.5 billion. That total represented the life time costs for 44,531 fatalities, 5.4 million non-fatal injuries, and 28 million damaged vehicles, in both police reported and unreported crashes during that year. Property damage costing \$45.7 billion accounted for the largest share of total RTA costs. Lifetime losses in market place production represented the second largest portion of total cost. Medical costs were the third highest category, totalling \$13.9 billion. Each fatality resulted in a discounted lifetime economic cost of \$702,000.

A study by Miller *et al.* (1989) on Crash Costs and Safety Investments in the US during 1986, estimated RTAs to cost society more than $38 billion per year, sapping 1.5% from the nation's productivity growth. Of this amount, about half resulted from lost productivity and housework, while the other half from the direct cost of crashes, including property damage, medical care, police, fire and ambulance services and other administrative and legal activities. The study utilised WTP values derived from how people behave in risky situations, to complement for non-monetary injury costs like PGS costs. The study adjusted the value estimates conceived in 25 studies (1986), to draw an estimate of $1.95 million for saving one average life. Therefore, the study suggested that expending up to $2.3 million to prevent one fatal crash would be rational public policy, although crash costs society only $500,000. Further, the study revealed that prevention of severe, nonfatal spinal cord injuries warrants even larger expenditures, and that the estimated rational investment to prevent an average nonfatal injury crash amounted to $22,000, while society's cost was $8,000.

Miller's figures are widely cited and used by several agencies in project evaluation worldwide. According to Haight (1994) they are reasonably consistent with the 1990 value (Department of Transport 1991) for Great Britain of £664,940, bearing in mind the inflated medical costs in the US but quite different from the Australian figure (Andreassen, 1992) of $A 625,000, or something like half a million US dollars.

The comprehensive approach (Human Capital and WTP values) was used in a research project in Sweden, bearing the name of its Swedish acronym (EVIS). The objective of the project was to determine costs of RTAs and occupational injuries in Sweden (Springfeldt *et al.*, 1997). The following cost components of RTAs and other occupational injuries were evaluated: (1) expenses for hospital care; (2) loss of productivity, and; (3) PGS costs. The HC method was used for calculating material costs. The *WTP* method was used to estimate effects of PGS. .

Data sources were Statistics Sweden's Work Injury Information System (ISA), which covers work-related injuries, and statistics from the Swedish Labour Market

Insurance' information system for serious injuries (TSI), which contains data on accidents causing injuries leading to more than 30 days of sick leave.

Calculations were made of the material cost to society of health care and production losses. The first step was to analyse accidents caused by vehicles and falls of persons. Cost calculations were then applied to each injury case. Medical costs for outpatient and in-patient care were estimated from general hospital information. Costs attributable to loss of production were assumed to correspond to estimated wages over the period the injured person was away from work, computed from average values by age, gender, etc. With regard to serious and fatal injuries, the day-value of total production loss due to sickness and premature death was calculated according to the economic-annuity method. The material costs were added to PGS costs. The Swedish estimate of the WTP value for a saved human life, was used. Severe injuries were regarded as having a PGS value of four times the material cost, and minor injuries 90 percent of such cost.

In total, serious-vehicle and fall injuries were estimated to cost, on average, about $150,000 per case, and ladder injuries about $100,000. On average, minor injuries were estimated to cost a total of about $5,000. Injuries resulting from the use of a portable ladder lead on average to material costs of about $10,000 per injury, $2,600 per minor injury, $90,000 for lasting injury, and $140,000 per fatal injury. Of total material costs, half the burden falls on health care, the other half on production. The material costs were added to PGS costs. The PGS value of a minor injury was about the same as its material cost (estimated at $2,500). For a lasting injury, the PGS value ($275,100) was about three times the material cost ($90,000), while for a fatal injury ($1,375,000) was about ten times the material cost ($137,500).

5.3 Conclusion

The RTA problem has received, and has continued to attract, increasing attention and interest from researchers working in various disciplines, including health economics, over the last decades. It is the practice nowadays that official estimates of the economic impact of RTAs are regularly prepared in most developed countries (Elvik, 1994). These evaluations were mainly intended to use in cost benefit analysis of safety programmes and measures. It is important to note here that the conceptual framework of these evaluations, like other areas of knowledge, went through historical evolution. During the early 1950^{th} and for several years, the perspective of most RTA evaluations was based on the Human Capital Approach. The approach takes the discounted future earnings (either gross or net of the individual's consumption) as an estimate of the loss to the community from premature death of an individual. The logic was that the 'loss to the community' consists of the net present value of productive years lost because of the fatality. Hence, the theme was to place monetary weights on the healthy time of individuals using market wage rates and the value of lost life was assessed in terms of present value of future earnings. In the first estimates that were made the present value of the consumption of the accident victim was subtracted from the present value of his or her production. In the early 1960s, this approach was abandoned in favour of the gross value of lost production, where consumption was no longer subtracted.

However, despite the improvements to the HC approach, it remains suffering from a number of measurement difficulties and methodological problems as well. One of these problems is its primary reliance on the wage rate as the sole parameter of value for human losses in terms of death and injury. The second is that economists argue that the approach is not consistent with the theoretical foundations of the CBA approach from welfare economics because it offers a narrow view of the utility consequences of the problem; restricted to impacts on labour productivity (Schelling 1968; Mishan 1971). Economists contend that the analysis of RTAs and roadway safety projects should be based on the principles of the CBA approach. The approach is firmly based on the theoretical traditions of *Paretian* welfare economics and the Kaldor-Hicks Compensation Tests. The purpose of the CBA is to identify the potential *Pareto* improvements; that is, situations where the maximum total sum of money that the gainers from a roadway project, for example, would be prepared to pay to ensure that the project, if were undertaken, exceeds the minimum total sum of money that the losers from it would accept as compensation to allow it to be undertaken. The fundamental point made by the approach is that the relevant notion of value embedded in welfare economics is that consumers who gain from a programme are willing to sacrifice (to compensate losers) to have the programme. It is this collective willingness to pay (willingness to sacrifice other goods and services to save one statistical life) which economists suggest should be the focus of the analysis of the RTA costs. According to Miller (1994) 'this CBA based approach is gaining an increased acceptance by economists for a number of other reasons: it is capable of addressing questions of allocative efficiency, of assigning values to health and non-health related goals, of determining which of them are worth achieving, given the alternative uses of resources, and of thereby determining which safety measures or projects are worthwhile' (Miller, 1994).

Towards the end of the 1970s, RTA prevention projects were enhanced, in most developed countries, by the extension of the WTP approach to the analysis of these projects. It is evident that the application of the WTP values in roadway safety projects has enabled, in several cases, the justification of the introduction of several RTA preventive measures, which were considered previously expensive or cost-ineffective.

However, it is important to mention that although economists theoretically favour the WTP approach, the application of the approach remains difficult due to the inherent difficulties in measuring WTP that is in addition to the ongoing conceptual conflicts concerning the proper techniques to use for designing the analysis. Due to this fact very few studies to date could be cited as being full evaluations using WTP methods. According to Drummond (1998) and Miller (1994) most of the published WTP evaluation studies are experimental in nature, attempting to explore measurement feasibility issues rather than being full CBA based evaluations.

For that and for other reasons as well, the majority of economists working in this area continue to rely upon the HC approach as the common approach for analysing the impact of RTAs, despite the methodological and measurement difficulties pointed out earlier in this review. A recent study (Elvik, 1994), reviewing RTA evaluations in 20 industrialised countries, maintained that 65% of those studies used the HC approach. A similar review by Miller sited 42 studies up to 1994 that can be considered full CBA-WTP studies in RTA analysis. However, the results of those studies were very different and as such the application of the approach remains very controversial.

Miller (1989, 1992, 1994), Elvik (1994), Blincoe and Faigin (1991, 1994) introduced the conceptual framework of the Comprehensive approach which combines the tangible monetary costs of RTAs consequences (health and material consequences), relating to medication, property damage and physical incapacitation - derived by the Human Capital approach - and the intangible WTP estimates of pain, grief and suffering. The value figures produced by the approach are considered by many economists as appropriate to use for cost benefit analysis.

CHAPTER 6

METHODS AND MATERIALS FOR ANALYSING RTA EPIDEMIOLOGY IN THE UAE

CHAPTER 6

RTA EPIDEMIOLOGY IN THE UAE

6.1 Trends of Morbidity and Mortality from RTAs in the UAE

6.1.1 Introduction

A retrospective analysis was conducted, based on secondary data obtained from the UAE official reports on RTAs, RTA injuries and deaths, on people of all ages in the seven Emirates of the UAE during the period 1981-1995. With an estimated 5% of RTAs going unreported in the UAE, mostly minor single vehicle accidents, virtually all significant RTAs in the UAE were included (MoI Annual Reports: 1981-1995). This high estimate for accident reporting is claimed by Police authorities and is achieved by law that insists that all garages and repair establishments do not attend any vehicle involved in an accident, no matter how minor it is, unless a police report on the accident is produced, with severe penalties for both drivers and garages which fail to comply with these measures. These standards are believed to help to reduce underreporting bias for RTA injuries and fatalities in the UAE to a minimum.

According to Police sources, road traffic accidents (RTAs) are defined in the UAE to include all traffic accidents that result in death, injury or property damage only (PDO) to road users. RTA deaths are defined to include all deaths that occur within 30 days from the accident. RTA injuries are defined to include all non-fatal injuries to motor vehicle occupants and non-occupants involved in RTAs. The annual crude rates of RTAs, RTA deaths and injuries (per 100,000 population and per 100,000 registered motor vehicles) were calculated to estimate the secular trends of the RTA problem in the UAE. The severity rates of injury and death per 1000 RTA (the ratio of injuries and fatalities to accidents) were also calculated to quantify the risk of injury or death in RTAs.

Prior to 1990, the UAE Police used to produce summary reports containing few of the details of RTA causal factors. Thereafter, improvements in these reports, especially the reporting of RTA causal factors according to Police opinion, permitted attempts to be made to determine the specific causal factors of RTAs. These factors include excessive speed, careless driving, personal factors (e.g. fatigue, sleeplessness, driving under the effect of medical drugs, etc.) alcohol, environmental and vehicle conditions. Hence, the data for 1990 to 1998 were analysed to describe the possible factors, from the Police viewpoint, that contribute to RTAs in the UAE.

6.1.2 **Study Area and Population**

The study area comprised the seven Emirates forming the state of the United Arab Emirates (UAE): Abu Dhabi, Dubai, Sharjah, Ras Al-Khaima, Fujairah, Ajman, and Umm Al-Quwain. All RTAs, RTA injuries and deaths, reported by Police authorities in the UAE during the period 1981 to 1995, were reviewed to investigate the problem of RTAs in the UAE.

6.1.3 **Data Sources**

The numerator data for the rates of RTAs, RTA injury and fatality were obtained from the Ministry of Interior Annual Statistical Report (MoI Annual Reports: 1980-1995), the Ministry of Health Annual Statistical Report (MoH Annual Reports: 1980-1995) and the Disease Prevention and Control Reports of the Ministry of Health (MoH-DPC: 1975-1998). Population denominator data were obtained from the UAE Annual Statistical Abstract (UAE-ASA: 1975-1998), the official UAE census of 1985 and 1995 and the UAE Vital Statistics Report (1975-1998). Comparative data were obtained from the US National Highway Traffic & Safety Administration (NHSTA), the published literature (Bener *et al.*, 1992; Elvik, 1995; Wyatt *et al.*, 1996) and the World Health Organisation (WHO) Statistics Annual (1985-1996).

MoI annual report represents the single true count of fatal and non-fatal RTAs in the UAE. It contains information such as the number of registered vehicles, number and frequency of road traffic accidents, injuries and fatalities, number of licensed drivers, drivers` age and nationality, etc. However, it is important to note that the data found in the MoI-ASR are mainly collected for security purposes. Due to that the report is rarely sufficiently comprehensive for epidemiological research purposes. For example, MoI-ASR reports actual deaths that take place within 30 days only from the accident. They do not include deaths that occur beyond that time interval.

The MoH-ASR gives a detailed count of mortality and morbidity in the UAE, together with detailed information on the general and specific causes of mortality and morbidity. Unfortunately, it classifies RTA fatalities with homicide, suicide, accidental injuries and other non-stated accidental deaths. For that reason, it is found less useful than MoI-ASR as a source of data on RTA-related deaths and injuries.

The MoH-DCPR deals exclusively with disease prevention and control. It covers communicable diseases in details, giving information on their prevalence and trends. Also, it gives a detailed count of chronic and non-communicable diseases, including complimentary data on accidental injuries from Al Mafraq hospital.

6.1.4 **Statistical Analysis**

Crude and specific rates of RTAs, RTA injuries and deaths were calculated using the following formulae:

RTA Fatality rate per 100,000 population =

$$\frac{\text{Number of deaths in the UAE from RTA during the year X 100,000}}{\text{Total UAE population}}$$

RTA injury rate per 100,000 population =

$$\frac{\text{Number of injuries in the UAE from RTA during the year X 100,000}}{\text{Total UAE population}}$$

Rate of RTAs per 100,000 population =

$$\frac{\text{Number of RTAs during the year in the UAE X 100,000}}{\text{Total UAE population (according to the census data)}}$$

Rate of RTAs per 100,000 registered vehicles =

$$\frac{\text{Number of RTA during the year in the UAE X 100,000}}{\text{Total number of registered vehicles during the year}}$$

Estimates of trends for RTAs, RTA fatalities and injuries in the UAE were achieved by using linear regression analysis.

All data variables were processed and analysed using the statistical programme SPSS: version 10. Tables and graphs were prepared using Microsoft Excel: version 97.

6.2 Future Forecasts of RTA Fatalities in the UAE

6.2.1 Forecasting Model for the UAE

Our model for the UAE was based on the following standard multiple regression equation (3), which has been used to analyse the functional relationship between RTA deaths (Y_j) and a number of explanatory variables denoted in the equation by the symbol (X_i).

$$Y = \beta_o + \beta_1 x_1 + \beta_2 x_2 + \ldots\ldots + \beta_p x_p + \varepsilon \qquad (1)$$

Which has been reduced to:.

$$Y = \beta_0 + \sum_{j=1} \beta_j \chi_{ij} + \varepsilon \qquad (i = 1, 2, 3, \ldots n) \qquad (2)$$

where,

- $\beta_0, \beta_1, \beta_2, \quad , \beta_p$ are the model parameters,
- ε is the random error estimate which accounts for the variability of Y which cannot be explained by the linear effect of the i^{th} independent variables,
- Y is the linear function of the i^{th} independent variables: ($X_1, X_2, \ldots.. X_n$)
- X_{ij} is the i^{th} explanatory variable in the j^{th} year.
- If we assume that the mean or expected value of ε is zero, our equation for the UAE can be written as follows:

$$Y = \beta_o + \sum_{j=1}^{19} \beta_{ij} \chi_{ij} \qquad (i = 1, 2, \ldots 7) \qquad (3)$$

where,

Y_j = Number of RTA fatalities in the j^{th} year,

β_0, β_{ij} = Intercept and Model parameters,

x_1 = Number of UAE population,

x_2 = Number of registered motor vehicles,

x_3 = Number of drivers < 40 years age involved in RTAs,

x_4 = Number of drivers killed in high speed driving,

x_5 = Number of drivers killed in careless driving,

x_6 = Number of RTA fatalities related by Police to alcohol/ drug use.

The factors of GDP and disposable income were introduced in the equation on the assumption that as income increases the value of time increases. Therefore, drivers are expected to increase speed in order to cut the cost of travel. Generally, greater speed may lead to more deaths and disabling injuries, though this might be offset by the fact that with higher incomes drivers and car occupants tend to exercise more safety and caution. In the meantime with increased GDP an increased expenditure on roadway infrastructure and roadway traffic safety would be expected. In the meantime with increased disposable income an increased expenditure on occupants' safety would be expected. Thus, the sign of the coefficient of the two variables is expected to be decided empirically by the net effect of the offsetting factors.

The factors of motor vehicles and the population were introduced in the model on the basis that RTA deaths essentially result from failure in interaction within or between these two roadway traffic factors. Thus, their effect is generally upheld as dominant by most researchers.

The factors of motor vehicle kilometres driven, number of drivers below the age 40 years, drivers killed due to high speed, careless driving and alcohol/drug use are directly related to RTA fatalities. Therefore, it was reasonable to introduce them in the prediction model.

6.2.2 **Data and Material**

The data on the numbers of RTA deaths were abstracted from MoI annual reports (1980-1995), the MoH annual statistical reports (1980-1995) and the MoH-DPC reports (1975-1998). The data sources on the UAE population, disposable income and GDP were the UAE-ASA (1975-1995) and the UAE vital statistics reports (1975-1998). In the UAE the data for motor vehicles kilometres travelled was not available. To estimate distance driven in the UAE we assumed that the number of kilometres driven per vehicle per year (25,000 kilometres) were constant over the years of the time series. The number of motor vehicles in the UAE was multiplied by that estimate for each year to yield the final estimation. The result was used as a proxy for distance driven in the model.

Smeed's formula was used to fit the UAE data to verify how best the model could estimate RTA fatalities in the UAE.

6.2.3 **Statistical Analysis**

ANOVA was used to estimate overall and individual significance of regression parameters. For overall significance the test statistic F was used to test parameters B_{ij} for significance. For individual parameters the t-test was used. According to statistical principles, the overall significance of the model was used as evidence for the suitability of the model.

Stepwise regression with backward iteration (*criterion*: probability of F to enter $<=0.05$, and probability of F to remove $>= 0.10$) was used to enter the explanatory variables (X_i) in the model. The method enters all independent variables in the equation and then sequentially removes them. The variable with the smallest partial correlation with the dependent variable (Y_i) is considered first for removal. If it meets the criterion for elimination, it is removed. After the first variable is removed, the variable with the smallest partial correlation remaining in the equation is considered next. The procedure stops when there are no variables in the equation that satisfy the removal criterion.

Missing values for variables were replaced with the variable mean. Parameters were estimated by OLS method.

6.3 Effectiveness of Seatbelt Legislation in the UAE

6.3.1 Study Design

This is an observational, historical (pre/post) case series study of individuals injured in RTAs and taken to Al-Ain hospital (the major trauma hospital in the eastern district of Abu Dhabi) alive. For the pre-evaluation (the case series of RTA victims injured before seatbelt legislation) the study recruited subjects injured during January to June 1998. For the post-evaluation (the case series of victims injured after the enactment of seatbelt legislation) the study recruited subjects during February to August 2000. Severity of injury was coded according to the AIS for all victims.

6.3.2 Data and Material

For the pre and post evaluations, the study used two abstraction forms (Appendices 3 and 4), designed in collaboration with trauma and orthopaedic specialists, working in the Faculty of Medicine of the UAE University and Al-Ain teaching hospital. These forms were used to retrieve primary data from medical charts of RTA victims at Al-Ain hospital in the UAE. Inclusion criteria were all persons who presented alive to the accident and emergency department of the hospital (ER) as a result of involvement in RTA during the time periods specified. The first form was used to retrieve data for the 'pre-evaluation' period from patients' medical charts. Using the ER registry, every fifth patient brought alive to the hospital was selected. Thereafter, a panel of orthopaedic surgeon, trauma specialist and nurses retrieved the data and completed the form. The second form, which is composed of two parts, was used to collect and retrieve data for the 'post-evaluation' period. An emergency nurse in Al-Ain hospital completed the descriptive details of the victim, in addition to filling in information relating to the mechanism of injury and the presence or absence of restraints, for every fifth person, meeting the inclusion criteria during the time period. After that the form was set aside until the patient was discharged from hospital. Then, orthopaedic surgeons and trauma specialists completed its second part, containing details of inpatient treatment and assessment of final outcomes including disability and lifelong complications.

Overall, the following outcomes were measured identically on both forms: the severity of injury among the injured population using the Abbreviated Injury Scale (AIS), the total hospital bed-days spent and hospital treatment (interventions at Emergency room, Intensive Care Unit, operation theatre and hospitals wards). Additionally, in the pre-evaluation the costs at the three stages of treatment: pre-hospital (intervention at roadside and/or on the ambulance), hospital (ER, ICU, operation theatre and hospital wards), and post hospital treatment were measured and valued.

6.3.3 **Assessment of Severity of Nonfatal RTA Injuries in the UAE**

6.3.3.1 **Background**

Researchers often combine patients into groups on the basis of injury severity for purposes of evaluating outcomes of roadway traffic safety interventions aiming to reduce or control RTA injuries. The extent of injury 'severity' has many possible dimensions, for instance the risk it poses to life 'risk to life', treatment period and the extent of temporary and permanent disability (Bull, 1982, 1984). In practice, the 'risk to life' has usually been the main criterion (Miller, 1989, 1993; Bull, 1982). Depending on the point of view or emphasis, various injury severity scoring systems have been advocated in the last four decades, such as the Abbreviated Injury Severity Scale (AIS), the Modified AIS (MAIS) the Injury Severity Scores (ISS), the New Injury Severity Score (NISS) the Glasgow Coma scale (GCS), the Trauma Score (TS), the Revised Trauma Score (RTS) and the **Tr**auma score and **I**njury **S**everity **S**core (TRISS) methodology (Yates, 1990). The generic principle behind these systems has been to give equivalent ranking orders of severity assessment to all types of injury. The degrees that these ratings relate to morbidity and/or final outcomes after major trauma remain controversial. However, the one that is widely held and easy to use is the AIS, which is based primarily on the professional experience and clinical judgment of physicians rather than statistical analysis (Baker, *et al.*, 1974; Bull, 1982; Yates, 1990; Gennarelli, 2001). Most research on RTA injuries use the AIS scale as the basis to estimate injury incidence and consequences (Miller, 1989). In this section a detailed explanation for the AIS and ISS systems is made first followed by a brief explanation for some other major approaches, namely: the GCS, the RTS and the TRISS.

The AIS scale was first conceived in 1969 (Yates, 1990). Its original purpose was to fill a need for a standardised system that provides equivalent rankings for injuries of different types and severity throughout the body regions (Baker, 1974; Bull, 1982; Yates, 1990, Durbin *et al.*, 2001). It classifies injuries by body regions "head or neck, chest, abdominal or pelvic contents, extremities or pelvic girdle and general" and by severity (1= minor, 2= moderate, 3= serious, not life-threatening, 4= severe, life threatening–survivable, 5 =critical, survivable – uncertain, 6= fatal, un-survivable) (Baker, *et al.*, 1974; Miller, 1989, 1993, Durbin *et al.*, 2001). The ranking order of severity is based on the criterion of 'risk to life', determined by clinicians. The scale has shown to correspond fairly well to ranking by treatment time and a consensus of surgical estimates of severity (Bull, 1975). For that reason, the scale has become accepted as the standard measure for injury severity assessment (Bull, 1984). In 1975-76 the American Committee on Injury Scaling of the Association for the Advanced Automotive Medicine (formerly the American Association for Automotive Medicine), the parent body of the AIS, defined and classified a list of approximately 500 AIS injuries, and published the first AIS dictionary (Gennarelli, *et al.*, 2001). The committee continued to modify the AIS to remain in touch with contemporary issues and by 1980 the second edition of the injury dictionary expanded AIS injuries by three fold (1600 types of injuries) and the descriptions of many of them were further improved (Gennarelli, *et al.* 2001). For example the brain injury section was updated to parallel contemporary research in head injury. By 1985 the third edition of the AIS dictionary was published, this time with the incorporation of descriptors that would allow coding of penetrating injuries. The revision also introduced unique code numbers to each injury to facilitate computerised use of the AIS. In 1990 another major update of AIS was released to expand the number and sophistication of injury descriptors with focus on the differences that would be useful for measuring impairment or nonfatal injury outcomes (Gennarelli, *et al.*, 2001). Also, this version addressed injuries to children and penetrating injuries. The AIS 1990 was further updated in 1998 to clarify several issues but it was not a major departure from the AIS 1990 (Gennarelli, *et al.*, 2001).

Notwithstanding its rapid revisions there were principles that have remained relatively stable to guide changes to the scale. These were as follows (Gennarelli *et al.* 2001):

1. AIS should remain a simple method, primarily based on the professional experience and judgment of the physician, to rank injuries by severity.
2. The AIS should be applicable to many causes of injury.
3. The AIS should be compatible to large and small-scale data collections.
4. Injury descriptors are organised anatomically, not physiologically.
5. The AIS severity is a single, time independent value for each injury
6. The AIS considers the injury not its consequences.
7. The injury AIS is more than a mortality or threat to life measure.
8. The described injury occurs to an otherwise healthy adult.
9. Each severity score reflects a single injury being present.
10. The severity is described regarding its importance to the whole body.

However, despite its consistency in measuring injury severity and providing equivalent rankings of injuries of different types in the different body regions, the originators of the AIS made no claim that the intervals between the ranks are equal or of linear nature (Baker, 1974; Bull, 1975, 1982). This meant that adding AIS values is not valid for measuring multiple injuries. Recognising this, researchers advocated various weights and modifications to encompass multiple injuries. The most satisfactory method, based on the AIS scale and adjusting to multiple injuries, was the Injury Severity Scores (ISS) transformation, developed by Baker *et al.* (1974). The method makes possible a description of the overall severity of injury in persons who sustain injury to more than one body region. The ISS assigns injury severity ratings on the basis of the AIS for each injury in all regions of the body (Durbin, *et al.* 2001. Then the AIS grades for each of the three most severely injured areas are squared and summed to obtain the overall maximum injury severity score (ISS). To operationalise the ISS a maximum of AIS injury is set to 5 so that the most severe multiple injury would be represented by three AIS 5 injuries giving an ISS 3X25 = 75. By convention, a patient with an AIS 6 in one body region is given an ISS score of 75 (Bull, 1982; Yates, 1990; Durbin *et al.*, 2001). Since the ISS is based on a sum of three squares of numbers 0-5 it does not provide a continuous series. For instance there is no 7 or 15. The scores 9 and 16 are found very common while 14 and 22 are unusual (Yates, 1990). Despite these limitations, the scale was found to better correlate with mortality as compared to the AIS grade for the most severe injury (statistically explaining half of the variance (49%) in mortality as compared to one fourth (24%) using only the AIS to identify and determine severity of multiple injuries) (Baker *et al.*, 1974). A recent study (Durbin *et al.*, 2001) assessed agreement between the AIS and the ISS generated scores using the weighted kappa (kappaw) coefficient for ordered data and the intraclass correlation coefficient for continuous data and the results were excellent. Both overall (intraclass correlation coefficient = 0.86, 95% confidence interval (CI) 0.84 to 0.89)), and when grouped into three levels of severity (kappaw= 0.86, 95%; CI 0.85 to 0.87). Agreement in AIS scores across all body regions and ages was also excellent, (kappaw= 0.86 (95% CI 0.83 to 0.87) (Durbin, *et al.*, 2001).

For all these reasons the ISS has become widely accepted and used for assessing the incidence and consequences of RTA injury. It has also become the method of choice for evaluating other types of general trauma (Bull, 1982; Durbin *et al.*, 2001). Also, a great advantage of the AIS and the ISS derived from it is that it can easily be used by researchers since it makes no demand for special or standardised investigations of patients outside what must be almost universal medical practice (Bull, 1982). Satisfactory AIS estimates can be derived from routine medical records and the further calculation of the ISS for estimating severity of multiple injuries is very simple. However, as pointed out earlier both scales are under continuous improvement and modification. For example, Brenneman (1998) recognised that the ISS does not take into account multiple injuries in the same body region. To enable that he suggested a New ISS (NISS), which provide a more accurate measure of trauma severity by considering the patient's three greatest injuries regardless of body region (Brenneman, 1998).

The Glasgow coma scale GCS) is the accepted international standard for measuring neurological state of casualties (Yates, 1990). The scale depicts neurological responses of the victim's (eyes, motor and speech), estimated in scores of 1-4, 1-6 and 1-5 respectively. The score may be represented as a single figure (for example, GCS=15) or as responses in each of the three sections (for example GCS=465) (Yates, 1990). The system has been found useful in epidemiological research, especially when used in conjunction with other trauma scoring systems as will be explained later in this section.

The revised trauma scale (RTS) combines coded measurements of respiratory rate, systolic blood pressure and the GCS to provide a general assessment of physiological derangement (Yates, 1990). The system was originally derived from the analysis of a large North American database to determine the most predictive outcome variables. The three variables are scored by coded values ranging between 0-4. Then each coded value is multiplied by a weighting factor derived from regression analysis of the database to reflect the relative value of the measurement in determining survival. The score, by convention, is taken upon arrival of victims in the accident and emergency department. The scale is found sound in assessing the effects of modifications in the system of care (Yates, 1990).

Recognising the fact that the degree of physiological derangement measured by (RTS and GCS) and the extent of anatomical injury measured by (AIS and ISS) are initial indicators of 'threat to life' posed by injury and that they are often taken in the absence of crucial determinants to life such as the age of the patient and the method of wounding, researchers devised a scoring system known by the acronym 'TRISS' to facilitate the inclusion of all these determinants when assessing injury outcomes. The TRISS (tortuously developed from **T**rauma score and **I**njury **S**everity **S**core) to combine the four elements - revised trauma score, injury severity score, age of the patient and whether the injury is blunt or penetrating – to calculate the probability of survival of the patient (Yates, 1990). The system calculates the probability of survival using the following equation:

$$Ps= 1/1+e^{-b}$$

Where e=natural logarithm and $b=b_o+b_1(RTS)+b_2(ISS)+b_3(A)$

$B_{0\text{-}3}$=Weighted coefficients based on major trauma outcome study (USA) data. These differ for blunt and penetrating injuries.

RTS= revised trauma score.

ISS= Injury Severity Score.

A= Age of the patient (score 0 if <54, score 1 if $\geq$ 55).

The development of the TRISS methodology has been a major advance in the measurement of injury severity. The system has a worldwide reputation of consistency and reasonable predication outcome (Yates, 1990). It has been found useful in quantification of trauma severity and allow for survival comparisons between trauma populations (Furnival *et al.*, 1999). Future improvement of the system is sought in the incorporation of additional information about pre-hospital care, the seniority of doctors attending the patient on arrival to hospital, the initial management and the timing of consultations and operations (Yates, 1990). At present, the use of the methodology is wide spread to audit systems of trauma care and the management of individual patients.

The injury severity scoring systems described in this section represent the major injury coding systems under use by the research community. As pointed out earlier, the generic principle of these methods is to give equivalent ranking order of severity to all types of injury. Among those systems the AIS and its derivative, the ISS, remain of fundamental importance to research on trauma in general and on RTA injuries in particular. The systems are known to provide consistent estimates of injury severity that fit well with treatment times and disability outcomes; a feature that helps understanding the magnitude of nonfatal RTA injuries. Another advantage is the ease of their measurement by clinical physicians and from patients' medical records. The ISS transformation also proved to facilitate the assessment of multiple injuries, which is very common in RTAs. Lastly, the wide use of the systems provides the ground for comparisons across countries. One major shortcoming of these injury-scoring systems is that they do not specifically address long-term risk of impairment, and therefore, overlook one of the most crucial elements of trauma (Miller, 1989, 1993; Furnival et al., 1999).

However, as stated before the basic purpose of the AIS and the ISS is to differentiate injuries by 'the threat they pose to life', not the cost, disability or trauma outcomes in terms of treatment and hospital stay. Nevertheless, given the lack of final outcome data on RTA injuries, which is essential for the accurate evaluation of the problem, and the fact that the only other source available is the police data, which takes no account of injury severity and subsequent outcomes, the only reasonable way to proceed, as suggested by many researchers, is to infer RTA injury outcomes on the AIS basis from patients medical charts and to use the resulting parameters to estimate the magnitude of the problem to the community (Hartunian *et al.* 1981; NHTSA, 1983; Miller *et al.*, 1989; Blincoe and Faigin, 1989; 1990, 1994).

6.3.3.2 Methods to estimate RTA Injury Severity in the UAE

This study used the AIS scale, which categorise each injury by body regions "head or neck, chest, abdominal or pelvic contents, extremities or pelvic girdle and general" and by severity (0=none, 1= minor, 2= moderate, 3= serious, not life-threatening, 4= severe, life threatening–survivable, 5 =critical, survivable – uncertain). In the absence of any routine injury coding system in the UAE, the study used trauma and orthopaedic specialists to estimate AIS injury severity, from RTA patients' records for both data samples. Only injury outcomes relating directly to RTA trauma during the initial 24 hours of assessment were scored. After grading all patients' injuries, each body region was categorised by the highest injury severity sustained in that region. For multiple injuries, affecting more than one body region, the AIS was assigned to casualties on the basis of the injury with the highest severity. For injuries with equivalent severity, priority was given according to the following anatomical order: head, spine, lower extremities, thorax, abdomen, upper extremities, neck, face and external.

6.3.4 Data Processing and Analysis

Data entry and analysis were performed using the statistical software package (SPSS version 10) and graphs were prepared using Microsoft Excel 97.

6.3.5 **Statistical Methods**

The Chi-square test was used to ascertain the association between two or more categorical variables, (p less or equal to 0.05 was considered as the cut-off value for significance).

CHAPTER 7

MODELS OF ESTIMATING THE ECONOMIC IMPACT OF RTAS IN THE UAE DURING 1995

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7.1 Outlines

The viewpoint of this study is a societal viewpoint (i.e. attempting to assess and quantify the overall human and material costs resulting from RTAs in the UAE), with particular emphasis on costs in the health care sector.

To achieve that the study adopted a comprehensive approach combining the Human Capital approach (HC) and Willingness to Pay Value (WTP) approach. It is established that estimates based on the HC approach are estimated on similar ways in most countries in the world, and therefore, the results will be comparable with results in other countries. That is in addition to the fact that HC values can be used to estimate savings from reducing a given number of injuries or crashes when appraising RTA control strategies; to estimate the direct economic impact of RTAs; and to evaluate its burden on health care resources. Since the HC does not place values on lost quality of life or PGS, the study attempts to cover that gap by combining WTP values derived worldwide.

The data sources for this study included secondary deterministic non-sampled data and stochastic sampled data and a combination of both types. The major non-sampled data sources were: the Annual Statistical Reports of the Ministry of Interior (MoI Annual Report, 1977-1998), the Annual Statistics Reports of the Ministry of Health (MoH Annual Report, 1981-1998), the Disease Prevention and Control Reports of the Ministry of Health (MoH DCP, 1981-1998) and the UAE Annual Statistical Abstracts (UAE-ASA, 1980-1998). These reports contained actual counts of all RTA fatal and nonfatal injuries by age, gender and location on yearly basis. Other data sources were: National UAE Accounts reports (1988-1995), medical charges and fees from official hospital records, qualitative data (gathered from experts and specialists) on medical procedures, time-series data for rates of interest, inflation and annual GDP growth, etc.

The sampled data included a series of prospective and retrospective *ad hoc* surveys carried out to establish reasonable evidence about RTA injury outcomes in the UAE. As mentioned before, the data on final outcomes of RTA injuries is not available from any source in the UAE. The police reports, which form the single complete source on RTA injuries, provide the crude counts of nonfatal RTA injuries only but no details about severity and outcomes of those injuries. To achieve a reasonable estimate of RTA injury outcomes the study investigated, retrospectively a sample, of RTA patients' records, collected from the major trauma hospital in Al-Ain Medical District (Al-Ain hospital), using systematic sampling. The study used the conventional principles of statistical inference and hypothesis testing to determine the following RTA injury outcome parameters: the severity of RTA injuries among casualties using the Abbreviated Injury Scale (AIS); the disability suffered by casualties per AIS category; the total hospital bed-days spent per AIS; the medical costs per AIS at three stages of treatment: pre-hospital (intervention at road side and/or on the ambulance), hospital treatment (intervention at Emergency room, Intensive Care Unit (ICU), operation theatre and hospital wards) and post hospital treatment (outpatient physiotherapy and home based rehabilitation).

The results provided the basis to apply the cost estimates per AIS category across the RTA injury patient population during 1995 to estimate the overall costs of those injuries in the UAE for that year. The chi-square test and the t-test were used, where appropriate, to test for significant differences in the distribution of categorical and continuous variables respectively (p less than 0.05 was considered significant).

Treatment and medication costs per AIS category (pre-hospital, outpatient and inpatient hospital costs) were determined prospectively by surveying expert opinion including that of consultants, specialists and hospital administrators. These data provided the necessary parameters to quantify the unit cost estimates of medical care, and productivity losses per AIS RTA injury. Data entry and analysis was performed using the statistical software package (SPSS versions 9 and 10) and MS Excel 1997.

The essential components of RTA costs investigated in this study were: workplace and home productivity losses, medical treatment and ancillary service costs, police administration costs, court and legal costs, insurance administration costs, property damages, in addition to the WTP estimates for pain, grief and suffering (PGS) or lost quality of life for individuals following RTAs. Property damage crashes only (PDO) were identified, measured and valued separately. The different components of RTA costs were further classified into direct and indirect cost components in addition to PGS. Direct cost components of RTA fatalities and injuries were: (1) Property damages; (2) The entire range of medical and ancillary care costs; (3) Insurance administrative costs; (4) Police, administrative and legal costs; and, (6) Workplace costs. Indirect cost components included: (1) Productivity losses in the workplace due to temporary or permanent disability; and (2) Decreases in home production from RTA fatalities and disabilities. That is in addition to PGS or lost quality of life, which occur to individuals following RTAs.

According to principles of the HC approach, other indirect costs also include traffic delay losses, payments to casualties' dependants from public assistance, private insurance, and other sources. The time and resources available for this project did not allow considering these latter potential elements.

The individual elements of each cost component per AIS category were identified through consultations with experts in Police, Insurance, Health authorities, Justice, etc. The resource components and quantities consumed/lost per AIS category were estimated and measured using different approaches. For example, productivity losses incurred in fatal injuries were estimated, using an epidemiological based criteria, *years of potential life lost* (YPLL), before converting them to monetary estimates, using market wage rates and shadow prices.

In this study a *Unit Cost* is defined as the monetary value of direct and indirect cost components per individual per AIS category. The measurement estimates of outcomes, according to AIS category, derived in the previous step were used to estimate the unit cost per AIS category. Thus, each *Unit Cost* comprised a number of cost components assigned per each AIS category. For example, a moderate injury (AIS3) unit cost comprised the following costs: temporary productivity losses, emergency service costs, medication, rehabilitation, insurance and police administration costs, legal and court costs, employer and workplace costs and property damage cost. Each unit cost per AIS, was estimated, using the conventional methods of statistical analysis. These derived unit costs per AIS category were applied across the injured population to estimate total RTA costs in the UAE during 1995.

Although, the proper price to measure material losses from RTA outcomes is the opportunity cost (the value of the forgone benefits because the resource is no longer available for its best alternative) the study adopted a pragmatic approach by taking the prevailing market price and wage-rates to estimate these losses, e.g. official hospital charges for medical treatment, market wage rates for productivity losses, etc. For non-marketed elements of RTAs, such as household productivity losses, shadow prices, estimated using the market replacement method, were used. Since many RTA outcomes are known to cause ongoing future losses, e.g. fatalities and permanent incapacitation, the estimation involved discounting to the present the future losses, of both fatal and non-fatal RTA injuries. These discounted estimates were also adjusted to count for inflation and natural economic growth. Sensitivity analysis was used to test for uncertainty.

The figures computed for the aforementioned components represent the value of direct and indirect monetary losses from RTAs. Other RTA outcomes, such as pain, grief, and suffering (PGS) - to individuals and the society, are not covered in these estimates. To cover the gap, the study followed the steps of Miller et al (1993), by building upon prior studies worldwide to estimate PGS costs: primarily those of NAHTSA (1990), Blincoe *et al.* (1990) and Miller *et al.* (1993). The PGS figures from these studies were used, after adjustment, for the UAE. The total figures, of the HC approach and adjusted WTP values, were used to produce the comprehensive value figures of RTA costs in the UAE, which could be used to generate cost/benefit ratios when analysing traffic safety measures in the UAE.

Therefore, our model consisted of, first: determining the unit cost per person per AIS category. This included estimating the direct and indirect unit costs of RTA injuries as described above, per casualty AIS category. Second, the study determined the number of casualties per AIS category, according to age group. Thirdly, the study multiplied the average unit costs by the total number of persons in each AIS category group, discounted future values, summed up the final results and conducted sensitivity analysis. Fourth, the the study computed and added up the cost of property damage and PGS per AIS category to estimate the comprehensive cost per AIS category.

7.2 Models for Estimating Costs of RTAs in the UAE during 1995

The detailed models for estimating unit costs per AIS category (for RTA fatalities and injuries) are described in the following sections.

7.2.1 Unit Costs of RTA Fatalities in the UAE during 1995

A Unit Cost of RTA fatality is described in this study as the average unit lifetime cost of human and material damages sustained by a victim. Hence, the unit cost of RTA fatality includes the following components:

1. Productivity losses at workplace.
2. Household productivity losses.
3. Emergency service costs.
4. Medical costs prior to death.
5. Premature funeral costs.
6. Insurance administration costs.
7. Legal and court costs.
8. Employer/workplace related costs

In the following sections the HC procedures, which have been used to estimate and compute each of these component costs, are explained and elaborated.

7.2.1.1 Productivity Losses at Workplace due to RTA Fatalities

One of the serious impacts of the RTA problem is that it causes premature deaths, which cause substantial productivity losses for societies. Since the viewpoint of this analysis is societal, and is based on the principles of the HC approach, the inclusion of productivity losses due to premature deaths is vital.

7.2.1.2 **Elements of Productivity Losses of RTA Fatalities**

Our model for quantifying RTA productivity losses per life lost in the UAE was based on the following principles:

1. An epidemiological approach, estimating the years of potential life lost (YPLL), was used to calculate the average years of potential life lost from RTA deaths in the UAE. Thus, the official retirement age in the UAE (65 years) was used as an <u>end point of productive life</u> to calculate premature deaths from RTAs in the UAE

2. For fatalities above the age 65, their productivity contribution was estimated on the basis of the court award payable to the heirs of the deceased (currently, AED 150,000; or an equivalent of US \$40,761).

3. To quantify workplace productivity losses, the annual average labour productivity amounting to AED 76,200 (equivalent to US\$20,706) was used for the estimation (National UAE Accounts: 1988-1995).

4. The present value of productivity lost/impaired was computed assuming an average productivity growth rate equivalent to the annual effective GDP growth rate over the period 1985-1996; found to equal 1.2%.

5. The following annuity formula for discounting, described in section 5.4 of the previous chapter, was used to calculate the present value of productivity lost per RTA fatality:

$$P = \frac{A\left[1-(1+k)^{-n}\right]}{k}$$

Where:

P = present value of productivity lost per individual.

A= Average productivity per individual during 1995.

k = an effective discounting rate combining both the effects of interest rate r and annual productivity growth rate g, such that:

$k = {}^{1+r}\!/_{1+g} - 1$ (i.e. k is calculated using the standard formula for calculating real rates from nominal rates).

6. The following mean rates (calculated for the period 1985-1996) were used to compute the discounting factor (k): the mean nominal rate of interest (r) = 5.29% (SD=±0.716); CPI deflator at current prices = 4.1% (SD=±0.0233), and GDP growth rate at current prices = 5.1% (SD=±0.104) (Appendix 8). Based on these estimates the effective discounting rate (k), adjusted for inflation and growth effects, was calculated and found to equal 4.2%.

7. A plausible range of the mean interest rate ±2SD was used to calculate two alternative effective discounting rates to explore uncertainty. Hence, an upper bound effective discounting rate of 6.772% and a lower bound effective discounting rate of 3.858% were used for sensitivity analysis.

7.2.1.3 **Determination of RTA Fatalities in the UAE during 1995**

The official MoH and MoI reports of the UAE, the major sources of RTA fatality data in the UAE reported 563 RTA deaths during 1995. However, those reported deaths are based on the definition that RTA deaths are those taking place within 48 hours of RTA injury only. This is known to underestimate the actual number of RTA deaths in the UAE (Bener, *et al.* 1994; Kutty, *et al.* 1995). To cover this gap, the study analysed a sample of RTA injury data (N=247) collected from Al-Ain hospital (the major trauma hospital in the Eastern District of Abu Dhabi) during the period from February to August 1998. The sampling method included every fifth RTA injured patient brought alive to the Emergency Room (ER) in Al-Ain hospital during the period of investigation. The analysis revealed that on average 3% of nonfatal RTA injury admissions to the hospital passed away. Applying this proportion to the nonfatal injury data, reported by police sources for 1995 (9820 nonfatal injury), increased RTA deaths by 127, thus, increasing RTA deaths during 1995 to 690 instead of 563.

7.2.1.3.1 Estimation of Years of Potential Life Lost due to RTA Fatalities

A year of potential life lost (YPLL) is an epidemiological based criterion to estimate the impact of premature mortality on a population. It is calculated as the sum of the difference between some predetermined end point of life and the ages of death for those who died before that end point (Sartwell and Last, 1981). The two most commonly used end points are the retirement age and the average life expectancy. To estimate productivity losses from RTA fatalities in the UAE the study used the retirement age 65 years to calculate years of potential life lost.

7.2.1.3.2 Elements for Estimating YPLL in the UAE

The calculation of YPLL due to RTA fatalities in the UAE was based on the following:

1. The compulsory retirement age in the UAE (65 years) was used as an end point estimate of productive life to calculate lost productivity from RTA deaths in the UAE.

2. For those who died at an age less than 17 years, their production is assumed to begin at the age 17 only and to end up at the age 65.

3. The mean age of each age group is taken as the age of death for that group.

4. For the groups younger than the end point (age 65) the YPLL was calculated by subtracting the end point from the mean age group.

5. For age groups older than age 65 the YPLL was considered as zero. That is based on the argument that productivity contributions to society cease beyond the retirement age.

6. The age specific YPLL was calculated by multiplying the group's YPLL times the number of persons in that age group. The age specific lost productivity

hours were calculated on the basis of average working days per individual in the UAE (i.e. 256 days) and official working hours per day (8 hours).

7. Total YPLL was achieved by summing up the age specific YPLL's.

8. Total YPLL estimates were employed to calculate lost workplace productivity and lost household productivity for RTA fatalities.

7.2.1.4 **Household Production Losses**

1. Unlike workplace productivity, household-work days were assumed to continue throughout the year, i.e. 365 days.

2. The official estimates of life expectancy in the UAE for 1995 (72 years) was used as an end point of life to calculate forgone household productivity losses in the UAE.

3. The average hours per day of household-work in the UAE were estimated on the basis of a survey conducted for this purpose. The survey revealed an average of two household-working hours per day.

4. Based on the market replacement method, household productivity per hour and gender was estimated on the basis of the hourly cost of labour required to replace household functions and duties. The prevailing 1995 minimum hourly wage estimates of the Ministry of Labour were used as a basis for the calculation, i.e. AED 17.4 (equivalent to $4.737).

5. The future losses of this component were discounted using k=4.2%.

6. The results of the estimation were added to the unit cost estimate per RTA fatality.

7.2.1.5 **Medical Costs Prior to Death**

As mentioned before the data sources on RTA injuries and deaths in the UAE give only the crude counts of those events leaving-out many important details, which are crucial for epidemiological and economic analysis. One of the missing details is the classification of RTA deaths by place of death (i.e. on the road, during transportation or at hospital), by medical procedures before death (i.e. first aid, emergency or medical intervention) and by duration of stay in hospital. These data are vital for estimating medical costs prior to death. In the absence of detailed data the study opted to use statistical inference to estimate the distribution of RTA fatalities by place of death, medical procedure and duration of hospital stay before death. To achieve that we analysed a data file of 247 RTA patients records, collected systematically, in one trauma hospital (Al-Ain hospital) during the first half of 1998. The analysis identified the pattern of distribution of RTA deaths according to place, medical procedure involved, number of hospital bed days and standard of medical intervention (basic, advanced or special) for patients suffering various injury severity scales from RTA trauma.

The resulting proportions were applied to the RTA fatality data during 1995 to estimate information relating to place of death (before or after arrival to hospital), medical procedures received prior to death (in the ER, the ICU or operating theatre) and the number of hospital bed days in hospital wards before death. To envisage the medical and therapeutic procedures for casualties suffering RTA fatal injuries the study consulted an expert panel of physicians working on routine treatment of RTA victims in ER, ICU, Surgical and Orthopaedic wards in Al-Ain hospital. The panel conceived three categories of medical procedures, following the practice of the UAE Ministry of Health, which classify procedures into small, medium and large operations. The panel assigned each RTA fatally injured casualty a single type of therapeutic procedure (basic, advanced or special) at each stage of referral, starting from the ER, the ICU, to hospital wards and operating theatres.

The official MoH charges for small, medium and large operation were used to estimate the equivalent rates for basic, advanced and special intervention at the ICU, hospital wards and operational theatres. Interventions at the ER, which involve lesser medial input, were estimated at lesser official rates. The cost of hospital bed days was estimated at the official MoH rates. Thus, the following official hospital charges and rates were used to estimate medical costs prior to death:

AED 200	Charge per hospital bed day
AED 6000	Basic intervention or operation (ICU + Ward)
AED 6000	Advanced procedure or operation (ICU + Ward)
AED 6000	Special (major operation at operational theatres)
AED 2000	per autopsy
AED 2500	X-ray, CT scan, laboratory costs, etc.
AED 200	Charge per intervention at the ER

Based on the distribution of RTA deaths, the information relating to medical intervention prior to death and the above charges and rates, the average medical costs prior to death were calculated.

7.2.1.6 **Premature Funeral and Repatriation Costs**

Average premature funeral costs per fatality were calculated by taking the difference in the value of funeral costs in the present versus the end of the expected life span of the fatally injured person, using the general interest rate for discounting. The model's reasoning is that funeral costs are normally expendable at the end of individual's life span. Thus, if those costs were invested rather than expended they could have achieved a profit, equivalent to the loss in interest gain, between the present and expected end of individual's life span.

Since 75% of the population in the UAE are expatriates from different countries, and since it is customary that expatriate victims together with their families, are repatriated to the their original countries following death, an element for repatriation costs per fatality was estimated and added to the funeral cost estimation. In general, the model for calculating funeral and repatriation costs per fatality was based on the following:

1. Current retirement age (65 years) in the UAE was taken as an end point for individuals' potential years of life in the UAE.

2. The mean age group was taken as the age of death for that age group.

3. The YPLL was used as a basis to calculate the present value of premature funeral costs.

4. A survey was conducted to estimate the costs involved in funerals in the UAE. The mean cost amounted to AED 850 per fatality. The resultant cost was adjusted to the year 1995 price levels using the official CPI (4.1%). The cost amounted to AED 715.68.

5. The average repatriation cost per expatriate victim was estimated by interviewing travel agents and was found to amount AED 4,500 per fatality. This figure was adjusted to the 1995 price rates and was found to amount AED 3,633. The cost was then added to the average funeral cost per RTA fatality (AED 715.68) to yield an amount of AED 4,348.68 per expatriate fatality.

6. The future value of premature funeral and repatriation costs per RTA fatality per age group was estimated using the UAE's effective rate of interest (4.2%).

7. The weighted average difference in funeral and repatriation costs (future versus present costs) for both citizens and expatriates was then calculated and taken as the average cost of premature funeral and repatriation costs in the UAE. The average cost was found amounting AED 6031.76.

7.2.1.7 **Emergency Services Costs**

Emergency service costs related to administration of RTA fatalities include police, fire and ambulance services costs. To estimate the police services cost in RTA fatalities in the UAE, first an analysis was made for a sample of fatal RTAs (N=46), obtained from police records of the Traffic Department of Al-Ain, to determine the number of officers required at the scene of the accident, the time and resources required for investigation, documentation, transportation and communication. The analysis indicated that on average 2 officers, 1 patrol car and 1 towing vehicle usually attend a fatal accident. The average wages and fringe benefits per police officer were multiplied by the average time spent at the site of the accident to derive the average police manning cost per accident. The result was adjusted to 1995 rates using the official CPI and was added to the average cost of overhead costs to estimate the unit cost of police attendance per accident.

To estimate fire services response costs, the study used data from the annual reports of the Civil Defence in the UAE (MoI Report: 1995). The data indicated that in 1995, Civil Defence attended 1400 fire events, out of which 497 (30%) were RTAs. Of all RTAs attended 87 (17.5%) were fatal accidents. To estimate the average cost of fire response per fatal RTA the study used information on expenses obtained from the Federal Department of Civil Defence in the UAE during 2000. Expenses per fire engine response included: overheads (for buildings, motor vehicles, fire engines and equipment), operating costs (manning cost, maintenance, communications, materials and consumables, water and electricity, fuel and lubricants), in addition to administration costs. The resultant estimate, per fire response, was adjusted to the 1995 rates, using the official CPI in the UAE (4.1%). To estimate the cost of fire response per fatal RTA the study used the proportion of fatal RTAs attended (17.5%) to estimate the average cost of fire response and the result was added to the cost of emergency services.

Ambulance costs were estimated by using data on costs from the Ambulance Department of the emirate of Dubai for the year 2000. The data included overhead expenses for buildings, medical equipment, vehicles, and other equipment (factored at a rate of 20% per year; equivalent to the official rate of depreciation), operating costs including vehicle and building maintenance, fuel, water, electricity and communication, consumables (bandages, dressings, drugs, etc.), manning cost (staff salaries, benefits and recreation) in addition to miscellaneous costs such as stationery, training and certification, auditing, seminars, conferences etc, that is in addition to the annual cost of administration. Those costs were added together to estimate the operating cost of ambulance services during 2000. The resulting figure was discounted at a rate of 4.1% (UAE's CPI rate – All Items) to adjust for the rates of 1995. To estimate the ambulance cost per call the study divided the total adjusted cost by the total number of calls made during 1995. The resulting figure was used as an estimate for the unit cost of ambulance response per fatal RTA in the UAE and was added to the unit costs of police and fire response.

7.2.1.8 **Insurance Administration Costs per RTA Fatality**

It should be noted that insurance payments and compensations paid to victims' heirs represent neither a cost nor a gain to society. In principle, they represent transfer payments only. Since the viewpoint of this analysis is societal those payments were excluded from the analysis. The only costs considered here were those relating to investigating and settling RTA insurance claims, i.e. RTA insurance administration costs. According to Blincoe *et al.* (1994) insurance administration costs are the difference between premiums paid to insurance companies and claims paid out by those companies to victims' heirs. The argument is that insurance administration cost is the company's cost of doing business and as such it forms part of the total cost of RTAs. Claims paid out by insurance companies are not identified separately as costs, as every claim is a compensation to members of society for losses such as productivity losses, medical expenses, property damage, etc., and is paid by members of society through premiums.

The data for insurance administration costs in the UAE was not available for the year 1995. To resolve the problem the study used time series analysis, based on data obtained from the UAE Annual Insurance Statistics Bulletins (1988-1992), to estimate insurance administration costs of RTA fatalities during 1995.

7.2.1.9 **Legal Administration Costs of RTA Fatalities**

The data on legal costs of RTA consequences are usually not available in routine RTA databases in most countries in the world. That is probably due to the fact that litigation on RTA cases usually takes a considerable period of time. For this reason most studies that have attempted to quantify legal costs of RTA opted to use statistical costing models.

To calculate the legal costs involved in RTAs we attempt to model the legal process using probabilities of progressing through the different stages of the legal process and the costs encountered at each stage. These probabilities are estimated on the basis of reported data and from consultations with experts and legal attorneys.

The data from the UAE Justice Department revealed that in 1995 all RTA fatalities were referred to elementary courts. Of this number 25% were referred to the appeal court or higher courts. These proportions were used to estimate the proportions of RTA fatalities referred to the different courts' levels in the UAE. The annual Insurance Statistics Bulletin for the years 1988-1992 also indicated that the percentage of motor vehicles involved in RTAs, and had full insurance cover, was 45%. Since insurance companies usually employ/hire lawyers to represent them before courts we assumed that 45% of surviving heirs of RTA fatalities were covered for attorney fees. In the mean time, since civil courts in the UAE usually assign attorneys for surviving heirs who fail to hire representatives we assumed that the remaining 55% of the surviving heirs all had attorneys representing them before courts and their costs were payable by the defendants. Court expenses in the UAE, which are customarily payable by the defendants' insurance companies, were found fixed for the last 10 years (at AED 1000). Attorney fees in the UAE were found to vary between 10 to 15% (an average of 12.5%) of the total compensation.

In the UAE also all registered vehicles are required to have a minimum third party insurance against a liability amounting to AED 250,000. In fatal accidents the law requires the defendant's insurance company to pay a fixed compensation for wrongful death amounting to AED 150,000 (called Diyatte) to the heirs of the victims in addition to indemnifying third party damages, e.g. municipal, road damages, etc., plus attorney fees. This applies for both types of motor-vehicles insurance in the UAE (third party and comprehensive insurance). Based on that and on experts opinion, we assumed that the initial attorney fees are customarily met at the elementary court level and that at the appeal court level and higher the only additional fees are those of the court fees and court administrative expenses. We also assumed that all legal expenses were compensated for in a successful lawsuit and thus our model for estimating average legal costs per RTA fatality consisted of the following:

$TLC_{RTAs} = E_{cas.}\,[RTA_{comp}\,(AF+CF+CME) + RTA_{3p}\,(AF+CF+CME)] +$
$AP_{cas.}\,[RTA_{comp}\,(CF+CME) + RTA_{3p}\,(CF+CME)]$

Where:

TLC_{RTAs}	= Total court and legal costs per RTA fatality in the UAE.
$E_{cas.}$	= Cases referred to elementary courts (100%=1).
AP_{cas}	= Cases referred to appeal court or higher (25%=0.25).
RTA_{comp}	= RTA cases, involving vehicles of comprehensive insurance policy, referred to courts (45%=0.45).
AF	= Attorney fees (12.5% of official compensation).
CF	= Court fees (AED 1000).
CME	= Court misc. expenses (estimated to amount AED 750).
RTA_{3p}	= Proportion of RTA cases involving vehicles of third party insurance coverage (55%=0.55).

7.2.10 **Employer Work Place related Costs**

An RTA fatality to an average worker in any business would cause employer/workplace costs including production down-time by other co-workers, overtime payment to compensate for the loss in man-power, payment for temporary help, production delays and finally the costs of replacement. Production downtime by other co-workers is meant to measure the indirect effect of the absence of the deceased worker in the production process, apart from his direct productivity loss, which is analysed separately in section (7.1.1.). Overtime pay and pay for temporary help are meant to measure the additional working hours required to supplement for the delays in production caused by the absence of the deceased worker. Based on a review of a sample of employment contracts obtained from Employment Agents in Al-Ain (N=66) it was found that replacing labourers in the UAE takes an average period of 4 month. The study added a further training period of 2 month for new recruits, and, therefore, estimated the average employer workplace losses due to production down time from RTA fatalities in the UAE to equal a minimum period of 6 month. Finally, the study used the average hourly earnings plus fringe benefits per labourer in the UAE during 1995 (AED 17.4), to calculate these costs.

In addition to the above cost estimate it should be mentioned that the replacement of workers in the UAE include other administrative costs, such as acquiring clearance and approval from the Labour Office and Immigration authorities to hire expatriate labours, which involve considerable expenditure. The cost of this additional component was estimated through a telephone survey with 4 private employment agencies in the UAE and was found amounting AED 5000 per individual labour during 2000. Adjusted to 1995 rates, using the CPI, this cost reached AED 4,089.93.

7.2.2 Unit Costs of RTA Injuries in the UAE during 1995

The elements of costs of RTA injuries are close to those of RTA fatalities described above but the methods for their calculation differ. The estimation is based on the distribution of RTA injuries according to injury severity which is based on the Abbreviated Injury Scale (AIS). The AIS scores from 1 (minor injury) to 6 (fatal) over 1200 injuries (Miller *et al.*, 1989). According to Miller et al. (1989) despite the fact that the AIS categories differentiate injuries by the threat they pose to life, not the cost, disability or trauma involved, the advantage of using it as a basis to quantify RTA injury medical costs, is that it supports using the health care cost data, which are usually classified along those lines. The extent of disability from RTA injuries per each AIS category was measured to assess productivity losses, in addition to hospital and rehabilitation costs.

The cost components of RTA injuries include the cost elements identified for RTA fatalities, with the exception of premature funeral costs and the addition of rehabilitation costs. As with RTA fatalities, only RTA injury-related costs were considered in this section. Property damage and lost quality of life were considered separately, and then added to the total cost per AIS injury category.

7.2.2.1 Cost Elements of RTA Injuries in the UAE during 1995

The cost elements of RTA injuries comprise the following items:

1. Temporary and permanent productivity losses at workplace.

2. Household productivity losses.
3. Short and long term medical costs.
4. Emergency services costs.
5. Insurance administration costs
6. Legal and court costs.
7. Employer/workplace Costs.

7.2.2.2 Productivity Losses at Workplace from RTA Injuries

Temporary and/or permanent productivity losses at workplace from RTA injuries are major sources of RTA costs. In principle, the best data for calculating losses from RTA injuries would be the final outcome data of RTA injuries. Since the present sources of RTA data in the UAE do not provide details on injury severity, disability and time losses due to RTA injuries, our first step was to identify the pattern of distribution of disability and time losses associated with each AIS category in the UAE, using the sample of RTA data obtained from Al-Ain hospital. The results provided the necessary parameters for disability and workplace-time losses per AIS category in the UAE. These estimates were then applied to the unclassified RTA injury data of 1995 to estimate workplace productivity losses from RTA injuries per AIS category per age group for that year.

7.2.2.2.1 Estimation of RTA Injury Severity and Disability in the UAE

The estimation of the unit cost of productivity losses per RTA injury in the UAE was based on estimates of disability from RTA injuries, according to AIS categories. Thus, the AIS injury categories were treated as the main categories of RTA injuries and the productivity losses associated with them were estimated by analysing the Al-Ain hospital RTA data. Disability from nonfatal RTA injuries was measured in terms of disability Adjusted Life Years (DALYs). DALYs measure the number of days/years of potential life lost (YPLL) summed with a comparatively adjusted measure of years of living with partial disability (YLDs) (WHO). In turn YDL measurement adjustments are based on AIS severity and duration of injury (average workdays absenteeism spent in outpatient and inpatient hospital treatment and rehabilitation) and age and sex of the individual involved.

The analysis revealed that out of the total number of cases of the sample (247): 3% were no injury, 42.1% were minor, 18.2% were moderate, 24.4% were serious, 8.3% were severe and 3.7% were critical. For accuracy these results were compared with data reported by Kutty *et al.* (1998) for RTA injury admissions to the orthopaedic and surgical wards of Al-Ain hospital during 1995. This hospital ward-based data gave similar proportions for some injuries: 26% for serious injuries, 10% for severe injuries and 5% for critical injuries, but different proportions for minor and moderate injuries (6% and 47%) respectively. The reason for the difference is that most minor injuries do not report to surgical and orthopaedic wards, where the latter sample was based, compared to the design of our data, which comprised the entire RTA injury population at Al-Ain hospital.

Applying the proportions obtained to the total number of RTA injuries reported by police during 1995 (MoI Report: 1995) provided a reasonable estimate for the distribution of RTA injuries, according to injury severity. The distribution of the 9,820 RTA injuries reported in 1995 would have thus been classified on AIS basis, as follows:

Type of Injury	AIS Code	No. Of Casualties	%
Minor injury	(1)	4459	45.4
Moderate injury	(2)	1787	18.2
Serious Injury	(3)	2396	24.4
Severe injury	(4)	815	08.3
Critical injury	(5)	363	03.7
Total		9820	100%

The average numbers of workdays' absenteeism due to minor, moderate and serious RTA injuries were estimated from the Al-Ain hospital sample data. Severe and critical injuries were considered totally disabling (Kutty, et al., 1998, Miller *et al.* 1989). Therefore, the study estimated workdays' absenteeism due to RTA injuries to be as follows:

Type of Injury	AIS Code	Days/Weeks off
No Injury	(0)	2 Days

Minor injury	(1)	2 weeks
Moderate injury	(2)	6 weeks
Serious Injury	(3)	12 weeks
Severe injury	(4)	Life disabling
Critical injury	(5)	Life disabling

The data was used to estimate productivity losses from RTA injuries in the UAE during 1995.

7.2.2.2.2 Measuring Productivity Losses from RTA Injuries

In addition to the above estimates, the Unit Cost estimate of productivity loss due to RTA injuries was based on the following:

1. Productive years of casualties were estimated to begin at the age 17 and end up at the age 65 (retirement age).

2. For those injured at an age lesser than 17 years, their production was assumed to begin at the age 17 only.

3. Productivity losses per AIS categories were estimated according to the number of days spent in hospital beds and the further days of rehabilitation (workdays' absenteeism). The contribution of injured victims above the age 65 years were estimated on the basis of the court award payable to the victims' heirs.

4. The mean of each age group was taken as the age of injury for that age group.

5. Average working hours per year and average hourly earnings in the UAE were used as the basis for the estimation. According to the Statistics of the Ministry of Labour (1995) the average working days per individual in the UAE were 256, the average working hours per day were 8 hours (2048 hours per year) and the average hourly payment was AED 17.4).

6. The productivity lost/impaired was computed on the basis of an average productivity growth rate equivalent to the effective GDP growth rate (1.2%).

7. The present value of productivity lost per AIS category per the mean age group and gender was discounted on the basis of the general interest rate in the UAE (4.2%).

7.2.2.3 **Losses in Household Production due to RTA Injuries**

As with the losses from RTA fatalities, RTA injuries also cause productivity losses at home. To estimate these losses the study used the time loss estimates due to RTA injuries derived from the analysis of Al-AIN hospital sample. The study followed the same principles outlined in section (7.2.1.4) to calculate household productivity losses from RTA fatalities in addition to the following:

1. Household workdays were assumed to continue throughout the year, i.e. 365 days, for victims suffering permanent disability.

2. Household workdays lost for lesser AIS categories were estimated according to the proportion of disability per AIS category in terms of the number of days spent in hospital beds and the further days spent at home for physical therapy and rehabilitation.

7.2.2.4 **Outpatient and Inpatient Medical Costs of RTA Injuries**

As pointed out earlier, the main data source for this study was the UAE's police records, which classify RTA outcomes on three categories: RTA fatalities, RTA injuries and property damage only (PDO). It was apparent that such crude classification would not reflect the far-reaching outcomes of RTA injuries, which might turn out following referral of victims to hospitals. On the other hand, the hospital sources do not report the final medical outcomes of RTA injuries in the UAE. Thus, it was necessary to identify the pattern of distribution of RTA injury outcomes in the UAE and to estimate the medical costs of each AIS injury category.

To achieve that the study further utilised the sample of RTA injuries obtained from Al-Ain hospital, to identify the pattern of RTA injury outcomes in the UAE and to estimate their medical costs. A panel of 4 physicians working in routine treatment of RTA victims at the Emergency Room (ER), the Intensive Care Unit (ICU), Surgical and Orthopaedic wards in Al-Ain hospital incorporated efforts to retrieve, from medical records, the essential medical and therapeutic procedures that each injured casualty in the sample had during his/her treatment. Those procedures, included: initial and later hospital care by medical professionals (doctors, nurses, physiotherapists) at the ER, the ICU and operational theatres, laboratory investigations, X-rays and CT scans, therapeutic equipment and prosthetic devices, pharmaceuticals and administration. To achieve a reasonable estimation the study conceived the following principles to carry out the estimation:

1. Based on RTA injury classification (AIS) at one hand, and the realisation that major medical interventions usually commence at the beginning of treatment on the other hand, three initial categories of medical procedures and interventions were proposed, following the practice of the MoH, for classifying small, medium and large operations. Accordingly, each AIS injury in the sample was assigned a single type of therapeutic procedure (Basic, Advanced or Special) during inpatient treatment in hospital (i.e. at the ICU, hospital wards and operating theatres). Outpatient treatment of injuries in the ER was charged separately.

2. The official MoH unit charge for non-health cardholders per operation and/or therapeutic procedure was used to estimate the rates for basic, advanced and special intervention at the ICU, hospital wards and operational theatres (i.e. AED 2000 for small procedure/operation, AED 4000 for medium procedure/operation and AED 6000 for large procedure/operation). A special charge was used to estimate the cost of outpatient treatment of minor injuries (AIS-1) at the ER (i.e. AED 200).

3. To estimate the costs of laboratory and X-ray investigations two packages of investigations, basic and advanced were proposed. Each minor and moderate

injury case (AIS-1 and AIS-2) was assigned a unit cost package of basic lab and X-ray investigation and each AIS-3, 4 and 5 were assigned unit cost package of advanced lab and X-ray investigations in addition to the initial basic package. The official rates of MoH for lab and X-ray for non-health cardholders were used to compute these costs.

4. To estimate the cost of therapeutics (e.g. antibiotics, analgesia, plaster coating, splints, traction, anatomical shoes, cervical collar, prosthetics, physiotherapy, etc.) three packages of therapeutics were proposed, basic, moderate and advanced therapeutics. Each AIS-1 injury case was proposed a fixed basic package of therapeutics (e.g. bandaging, cervical collar, analgesia, IV fluids, etc.). Each AIS-2 injury case was assigned a fixed package of moderate therapeutics (the basic therapeutic package in addition to splints and traction). Each serious, severe or critical injury case was proposed an advanced therapeutic package (the moderate package in addition to prosthetics, etc.). The official rates of MoH for non-health cardholders were used to compute these unit costs.

5. Hospital bed days were charged according to MoH mean rates for non-health cardholders (AED 200 per day) and their cost was added to the costs of medical procedures, lab and X-ray investigations per AIS.

6. The physical quantities of the various components of treatment for each patient were multiplied by their respective cost and were added up to derive the cost per AIS category per patient. The mean medical cost of RTA injury per AIS category was computed using descriptive statistics. Future medical costs for AIS 4 and 5 were discounted using the adjusted general interest rate in the UAE (4.2%). These Unit Costs were adjusted to the 1995 rates, using the official CPI. These costs were used as a proxy for the Unit Cost of medical inpatient treatment of RTA injuries in the UAE during 1995. A plausible range of the mean medical cost per AIS ± 2SD was used for sensitivity analysis.

7.2.2.5 **RTA Injury Outcomes and Medical Costs during 1995**

Since the severity of RTA injury did not change much in the UAE during the period 1995-1998, according to the trends analysed by this study (Section 8.1.5), the parameters derived in the previous section were applied to the data, reported by police, for RTA injuries in the UAE during 1995. The results provided reasonable estimates for outcomes of nonfatal injuries that occurred in 1995, including diagnostic and outpatient care at the ER, inpatient therapeutic procedures at the ICU, operating theatres and hospital wards and the number of hospital bed days for the various AIS categories. Each AIS category was assigned a Unit Cost estimate of outpatient and inpatient medical costs. These unit costs were multiplied by the respective estimate of the numbers of casualties per each AIS category during 1995 to obtain the medical costs of RTA injuries in the UAE during that year.

7.2.2.6 **Cost of Police, Fire and Emergency Medical Services**

The elements of emergency service costs of nonfatal RTA injuries were similar to those described for RTA fatal injuries. They included police services cost, fire services cost, and ambulance and emergency services cost. The study used the following steps to estimate the Unit Cost of these three elements:

1. The study assigned an element of police response cost, equivalent to the estimate derived for RTA fatalities, to all RTA injuries in the UAE. This was based on the fact that all nonfatal RTAs in the UAE are required by law to be reported to police authorities and no action can be taken before arrival of police to the scene of the accident. According to the recent UAE police reports, unreported RTAs formed less than 5 per cent of total crashes, and were mostly minor self-caused accidents (MoIAR, 1997). Therefore, it could be argued that police attendance at RTAs in the UAE usually cover more than 95 percent of total RTAs per annum, and possibly 100 per cent of those involving moderate and higher AIS categories.

2. To estimate Fire response for RTA injuries the study used the Civil Defence data of 1995 to determine the percentage of RTA injuries that required fire

response. The study used the unit cost estimate of fire response derived for fatal RTAs and the proportion derived for fire attendance per RTA injuries during 1995 to estimate the respective unit cost per RTA injury. The results were added to the average unit cost per police response. To facilitate estimating the unit cost of police and fire response per RTA casualty the study used the estimate drawn by Bener *et al.* (1992) for casualty involvement per RTA (1.74 injury patient per accident). The resulting estimate for police and fire response per RTA was divided by 1.74 to estimate the individual cost per patient.

3. Ambulance and emergency medical services costs per nonfatal injury were estimated on a similar basis as police and fire unit costs. Firstly, the study used the Al-Ain hospital-sampled data to estimate the proportion of RTA injuries per AIS category reported to have had ambulance transport to hospital. Thus, the proportion of 6% was used to estimate the number of RTA injuries that had ambulance response during 1995. Secondly, the study used the unit cost estimate of ambulance services per RTA fatality as basis to estimate the cost per RTA injury. These costs were multiplied by the proportions derived for ambulance response per AIS category to estimate the Unit Cost of ambulance response per RTA injury. The results were added to the average unit cost of police and fire responses to estimate the unit cost of police, fire and emergency interventions per AIS per RTA injury.

7.2.2.7 **Insurance Administration Costs of RTA Injuries during 1995**

As mentioned before insurance administrative costs are the difference between premiums paid by motor-vehicle owners to insurance companies and claims paid out by them. It is their cost of doing business and is part of the total cost. Since the administrative efforts required for settling insurance claims resulting from RTA injuries do not differ from those required for settling claims involving RTA fatalities the study decided to use the estimates produced for RTA fatalities (section 7.2.1.8.) for RTA injuries during 1995.

7.2.2.8 **Legal and Court Costs of RTA Injuries during 1995**

The model used for estimating the legal costs of RTA injuries was based on the assumptions used for RTA fatalities, except the following modifications:

1. Instead of the 'Diyatte', the calculation of legal attorney fees was based on the average compensation paid for human and material damages resulting from RTA injuries.

2. The average compensation for injuries was estimated by dividing the total compensation paid by insurance companies during 1995, for human damages due to RTA injuries, by the number of RTA injuries during that year. The figure was found amounting AED 18,933 for 1995. The study used the same percentage (12.5%) to compute attorney fees per AIS category.

3. The UAE police and legal sources indicate that half of RTA injuries achieve compensation through legal actions but they do not identify the severity of injury or damage associated with those claims. However, based on informed guesses from police and legal sources, the study estimated that one quarter of minor injuries, one third of moderate injuries, half of serious injuries and ninety percent of severe and critical injuries achieve compensation by legal means.

Based on those assumptions, our model for estimating the unit cost of legal and court services per AIS per RTA injury becomes as follows:

$$TLC_{RTAs} = E_{cas.} [RTA_{comp} (AF+CF+CME) + RTA_{3p} (AF+CF+CME)] + AP_{cas.} [RTA_{comp} (CF+CME) + RTA_{3p} (CF+CME)]$$

Where:

TLC_{RTAs}	= Total court and legal cost per AIS category per RTA injury.
$E_{cas.}$	= Cases referred to elementary courts (50%=0.50).
AP_{cas}	= Cases referred to appeal court or higher (25%=0.25).

RTA_{comp}	= RTA cases, involving vehicles of comprehensive insurance policy, referred to courts (45%=0.45).
AF	= Attorney fees (12.5% of average compensation).
CF	= Court fees (AED 1000).
CME	= Court misc. expenses (estimated to amount AED 750).
RTA_{3p}	= Proportion of RTA cases involving vehicles of third party insurance coverage (55%=0.55).

To compute the average unit legal and court cost per AIS category in the UAE during 1995 we multiplied the result obtained from applying the formula by the estimated percentage share of each AIS category of RTA injury.

7.2.2.9 **Employer/Work Place related Cost of RTAs in the UAE during 1995**

An RTA injury to an average worker in any industry would cause employer/workplace related costs including productive down-time by other co-workers, overtime payment to compensate for the loss in man-power, payment for temporary help, production delays and finally the costs of a replacement for totally disabled victims. Productive downtime by other co-workers is meant to measure the indirect effect of the absence of the injured worker in the production process, apart from his direct productivity loss, which is analysed separately. Overtime pay and pay for temporary help are meant to measure the additional working hours required to supplement for delays in production caused by the absence of injured workers. The costs of replacement for permanently disabled include advertising for vacancies, selecting applicants, conducting interviews, getting clearance and approval from the Labour office.

Thus, it is clear that the approximation of this item, in details, will require a substantial amount of work and data that is not available from any source. In view of this fact, the study opted to use a more crude method to estimate the cost of this component, through the following:

1. A survey was conducted to estimate the following parameters:

a. The average duration required replacing those who suffer permanent disability (severe and critical injury victims).

b. The average expenditure required recruiting a replacement for disabled victims.

2. The average days of work absence per AIS for those who suffered serious or lesser RTA injuries estimated from Al-Ain hospital sample were used.

3. The foregoing parameters were used to calculate workplace related productivity losses incurred due to RTA injuries per AIS category and the amount of expenditure required replacing permanently disabled victims.

4. The study used the average hourly earnings plus fringe benefits per labourer in the UAE during 1995 (AED 17.4), to calculate these costs.

7.2.3 **RTA Property Damage Costs in the UAE**

In addition to physical human damages of injury and death, RTAs cause considerable property damages to the victims, other road users and road environment. These include vehicular damages, road environment damages for electric poles, road signs, traffic signals, rail boundaries, other public utilities, etc. Additionally, the most common RTAs are those involving no injury, also known as property damage only crashes (PDO). They are known to contribute significantly to the total cost of RTAs (NHTSA, 1994). Unfortunately, the UAE traffic sources report the number of RTAs irrespective of the number of motor vehicles or casualties involved and, therefore, the data for the number of motor vehicles damaged in RTAs is not available from these sources. In the following sections a brief account of the methods used in estimating the number of motor vehicle damages and the unit costs of these damages is given.

7.2.3.1 **Property Damages related to RTA Fatalities and Injuries**

Elements of costs included in this component are vehicular and roadway repaired and un-repaired damages. The data sources were the UAE Annual Insurance

Statistics reports (UAE-AIS, 1988-1992), which gives annual counts of human and material damages from RTAs, number of comprehensive and third-party insurance policies, amounts of premiums paid, number of vehicles involved in RTAs, other material damages, outstanding claims and claims paid to insurers. Detailed insurance data was not available for the year 1995. To enable estimation for that year the study used the data of 1992 to calculate the unit cost of property damage from RTAs during 1992. Those figures were then factored annually, using the CPI rate (4.2%) to approximate the unit cost of RTA property damage per casualty during 1995. The study used the resulting cost estimate as an estimate for the cost of property damage per casualty per AIS category during 1995.

7.2.3.2 **Property Damages Only (PDO) RTAs**

According to principles of HC approach, the costs of property damages only (PDO) crashes include household and workplace productivity losses, insurance administration costs, emergency service (police and fire) costs and property damages.

The study estimated the number of vehicular (PDO crashes) in the UAE during 1995, using time-series analysis. Based on insurance data of 1985-1992 the number of vehicles involved in PDO crashes increased annually by a mean percentage rate of 17%. Thus, it could be argued that by 1995 the number of PDOs increased to reach 81,279. To estimate workplace and household productivity losses per PDO the study used the average work-absence days in the UAE due to RTAs, estimated from the Al-Ain hospital sample (section 7.2.2.2.1) and the hourly earnings in the UAE during 1995. The study used the same cost averages drawn for insurance administration costs, emergency (police and fire) and property damage costs to estimate the average PDO costs in the UAE during 1995.

7.3 Methods to Estimate Comprehensive Costs of RTAs in the UAE

The comprehensive costs of RTAs attempt to measure the tangible RTA losses (direct and indirect costs) and the intangible losses (PGS) to individual victims and to the society. The study used the HC approach to estimate the tangible losses of RTAs. However, other intangible losses, such as PGS remain beyond such monetary estimates. Economists use the WTP approach to place value on such losses. As pointed out before, those WTP based approaches include 'the contingent valuation method', 'the revealed preference valuation method' and 'observed market behaviours method'.

The time and resources available for this study did not allow for an attempt to measure these intangible aspects of RTAs. However, to fill the gap the study attempted to combine results of estimates drawn worldwide for these consequences. The review of the literature using WTP approach gave diverse estimates of US$ 1 to 7 million per statistical life saved (Elvik, 1993; Miller, Luchter and Brinkman, 1989; Miller, 1993; Blincoe and Faigin, 1992, 1994; Jones-Lee, 1992). Yet, for nonfatal RTA injuries there was little similar information. For these reasons the study relied primarily on two structured reviews made by Miller *et al.* (1989, 1993) and Elvik (1993) for WTP studies. The first review, which comprised 25 WTP studies (Miller *et al.* 1989) gave a mean 'rational investment level to enhance the safety of the American public" to amount US$ 1.95 million to save one life. Miller updated this initial review in 1993 (Miller *et al.* 1993).

Miller's second review comprised 47 WTP studies, after eliminating those with significant flaws and adjusting for age and population, income, perceived versus actual risk and the discount rate, yielded a 1988 mean and median statistical value of life amounting to US$ 2.2 million with a standard deviation of $ 0.65 million (Miller, *et al.*, 1993). Miller combined these estimates with ratings for physical impairment to compute estimates for functional capacity reduction from nonfatal RTA injuries. The resulting figures were used to determine estimates for pain, grief and suffering and lost enjoyment of life per AIS category, after subtracting the monetary components of RTA costs (the direct and indirect monetary costs of RTAs). The resulting figures ranged from US$ 9,220 for minor injuries (AIS 1) to US$ 2.1 million for severe and critical injuries (AIS-5). To validate his results Miller (1993) evaluated injury states on as many scales of reasonable quality, using the median utility loss across those scales to calculate the 'rational investment levels' of injury avoidance. He confined the analysis to some extremely severe injuries (called fates worse than death). He normalized all of the utility values so that death has a utility of zero and 'perfect health' a value of one. The calculations were based on percentage of functional losses averted for various such fates combined with utility of this loss, estimated by sample surveys. The results confirmed his initial estimates. As confirmed by Haight (1994) Miller's figure is now widely cited and used by several agencies in project evaluation in the US. Additionally, the estimate was found consistent with the 1990 value of Department of Transportation for Great Britain of £ 665,000 (bearing in mind the inflated medical costs in the US) (Haight, 1994).

On the other hand, Elvik (1993) adapted the framework of Miller described above for estimating the rational investment levels per AIS categories. After reviewing the WTP literature, he proposed an estimate of 10 million Norwegian kroner (equivalent to US$ 1,350,000 in 1993) for 'a reduction of risk corresponding to one fatal RTA injury' as the best WTP estimate from the literature. For other levels of injury severity the author used the health state index of 'quality adjusted life years' (QALYs) to estimate the proportional losses in quality of life pertaining to these injuries. These proportions were then multiplied by the aforementioned WTP estimate to approximate the monetary value of decreases in quality of life due to nonfatal RTA injuries. His adjusted estimates gave 112,000 Norwegian kroner for slight injury (equivalent to AIS-1) and 2.2 million kroner for very severe injuries (an equivalent to AIS-5). Despite his estimate for fatal injuries, which is 30% lesser than the US estimate, Elvik's estimates for nonfatal injuries were quite different.

To determine the value of statistical life in the UAE our study adapted the methods laid by Miller *et al.* (1989, 1993). However, noting that most of WTP estimates for the value of statistical life were based in developed countries and that such estimates seldom exist in developing countries, and; to account for the differences which are known to exist in 'perceived utility preferences towards safety' among people living in developing countries, compared to those living in developed countries, based on the notion that safety is a function of income, and; in view of the resources and the time span available for this project, the study adapted Miller's estimate for the value of life of 1993 for the UAE after adjustment.

To adjust Miller's figure ($ 2.2 million per fatal injury) for the UAE's 1995 cost evaluation, firstly, the study used the CPI (All Items) to upgrade the figure to the rates of 1995. Secondly, a special index was calculated by dividing the per capita income in the UAE by that of the US over the 1990s. The resulting ratio was used to account for the differential in 'perceived utility towards safety' between the US and the UAE to estimate the UAE figure for the value of statistical life.

To calculate estimates for reduced quality of life for other categories of nonfatal injury in the UAE the study used a procedure laid by Elvik (1993) estimating decreases in quality of life pertaining to RTA injury to be proportional to the number of 'lost years of living with perfect health' entailed by these injuries. The losses were based on the results of a detailed sample survey of the daily life of RTA injury victims. A severe injury for example was considered corresponding to 8% of the loss in case of a fatal injury (Elvik, 1993). Hence, the cost of lost quality of life for a serious injury (AIS-3) was estimated to be AED 472,000. Following the same approach and using the same index the costs of lost quality of life for other levels of RTA injury severity were calculated.

To determine estimates for pain grief and suffering for the UAE the study again adapted the procedure laid by Miller (1993), deducting the monetary components of nonfatal RTAs from the WTP estimate, leaving behind a "pure" lost quality of life cost in the UAE.

7.4 Methods to Estimate Savings from Seatbelt Legislation

The comparative analysis of the pre and post seatbelt evaluations (Section 8.3) provided the basis to determine the incremental difference in RTA injury outcomes per AIS category, following the enforcement of seatbelt legislation. To measure the reduction in RTA outcomes per AIS if those injured or killed in RTAs during 1995 had selected to use seatbelts, the study used the rates and ratios calculated for injury severity in the post evaluation period to estimate RTA outcomes, based on the total number of RTA injuries during 1995. To quantify the savings from this decline in monetary terms, the study used the cost estimates drawn in the previous analysis of nonfatal RTA injuries in the UAE during 1995. The unit costs per AIS category per casualty drawn in the analysis were used as measurement units to quantify RTA outcomes in monetary terms. The cost elements of those injured while using seatbelts were assumed not to differ of those, who were injured while not using seatbelts. The difference was in injury outcomes and disability and, therefore the cost of treatment, rehabilitation, workplace and household productivity. Thus, the elements of property damage, emergency services, police, court and insurance administration were assumed not to differ since the use of seatbelts do not make much difference in these respects.

7.4 Summary

To assess and comprehend the true impact of RTAs in the UAE, including its burden to the health care sector, the study took a societal viewpoint. To achieve that the study used the CBA based approaches - the HC and the WTP approaches - to quantify the material and human losses caused by RTAs. The data sources ranged from deterministic non-sampled sources, including MoH annual reports, MoI annual reports, Annual UAE Statistical Abstracts, etc. Sampled and qualitative data (informed specialists' opinion) were also used as a source of information to infer the necessary parameters for injury severity, incapacitation, medication costs, legal and police costs, etc. The essential elements of RTA costs were workplace and home productivity losses, medical and ancillary services costs, police administration costs, court and legal costs, property damage, in addition to estimated WTP values, derived from the international literature, to compensate for pain grief and suffering. The study took a pragmatic costing approach by combining prevailing market prices and wage rates to estimate the resource use associated with RTA outcomes, that is in addition to shadow prices for non-marketed RTA elements. The results were discounted to the present by using the average market rate of interest in the UAE. These rates were adjusted to count for inflation and natural economic growth. Sensitivity analysis was used to account for uncertainty.

Therefore, the model attempted to determine the unit costs of RTA injuries in the UAE, through estimating the direct and indirect components of RTAs per individual's casualty scale, age and gender. The value figures of these unit costs were adjusted to the present through discounting. Finally, The model estimated the overall costs of RTAs through multiplying the derived average unit costs for the various components of RTAs by the total number of victims in each AIS scale to determine the final results. The model added the WTP values to estimate the comprehensive loss of RTAs in the UAE.

CHAPTER 8

RTA TRENDS, FUTURE FORECASTS AND AN EVALUATION OF EFFECTIVENESS OF SEATBELTS LEGISLATION IN THE UAE

CHAPTER 8

RTA TRENDS, FUTURE FORECASTS AND AN EVALUATION OF EFFECTIVENESS OF SEATBELTS LEGISLATION IN REDUCING INJURY IN THE UAE

8.1 Trends of RTAs in the UAE during 1981-1995

8.1.1 Introduction

Between 1980 and 1995 the size of the UAE population increased at an average rate of 8.5% per year. This high percentage was achieved due the influx of expatriate workers in the country following the boom in oil prices during the 1970s and 1980s (Table 1). Likewise, the number of registered motor vehicles increased at a rate of 9.5% (Table 1). These rising trends were accompanied by increasing numbers of RTAs, RTA injuries and fatalities (Table 1 and Fig. 1). The underlying factors associated with these increased trends were diverse and complex. The comparison of the UAE's mortality rates from RTAs with the equivalent rates in developed and developing countries revealed that RTAs present clearly a grave public health problem in the UAE.

In this section we present the results of the analysis of the trends of morbidity and mortality from RTAs in the UAE during the period 1981-1995, the comparison of the UAE rates with those of developed countries, and an analysis for the information available on possible causes with a view to identify the most useful direction for future research on roadway safety in the UAE.

8.1.2 Trend of RTAs in the UAE during 1981-1995

Table (1) presents the UAE numbers of population, motor vehicles, RTA injuries and deaths in he UAE during the period 1981-1995. Table (2) presents the crude rates of RTAs, drawn on the basis of demographic factors, including resident population and number of registered vehicles. These rates were calculated using the formula described in the methods section earlier.

The numbers of RTAs has been declining throughout the period 1981-1995 (Table 1). From 1981 to 1985, the annual average rate of decline was 2.6%. Over the second half of the 1980s the number declined more steeply at an annual average rate of 28.5%. However, through the years 1992 to 1994 the numbers of RTAs increased substantially by an average of 11% before dropping down by 6.8% in 1995. Time series analysis of the numbers of RTAs, using linear regression, revealed an overall average declining trend of -337 per annum (p=0.007); equivalent to an annual average decline of 337 RTAs (Table 2-A).

The rate of RTAs per 100,000 population showed an overall-declining trend during 1981-1995 (Table 2). Despite the steady increase in the UAE population (Fig. 1) the rate of RTAs per 100,000 population declined from 1924 in 1981 to 760 only in 1995, a 60.5% decline (Fig. 2). Between 1981 and 1985 the rate declined by 17%; the decline steeped throughout the second half of the 1980s when it further fell by 56%; between 1991 and 1995 the rate declined more slowly by 10% (Table 2). Over all, the rate of RTAs per 100,000 population declined by an average linear trend component of -96.6 (p< .001) between 1981 and 1995.

Table (1)

Numbers of RTAs, RTA Deaths and Injuries in the UAE
(1981-1995)

	Resident Population	Number of Registered Vehicles	Number of RTAs	Number of RTA Deaths	Number of RTA Injuries
1981	1122840	192031	21360	460	6214
1982	1186300	208444	24647	482	6580
1983	1225490	223899	21111	450	5717
1984	1265100	239212	19522	314	5389
1985	1306200	253229	20789	288	5601
1986	1411650	247794	18330	310	6214
1987	1517100	254539	17653	343	6394
1988	1587100	271889	19479	336	7246
1989	1633200	293582	16195	372	7889
1990	1844300	303284	15607	394	8524
1991	1908800	309539	15269	490	8695
1992	2011400	344850	17533	510	9641
1993	2083100	399480	17759	567	9817
1994	2230000	447867	19397	600	9781
1995	2377453	428149	18071	563	9820

Table (2)
United Arab Emirates Traffic Fatality Rates by Population
<u>1981-1995</u>

Year	Total Number of Accidents	Resident Population	Number of registered Vehicles	RTA Rate per 100,000 Population	RTA Rate per 100,000 Motor vehicle
1981	21360	1,110,300	192031	1942	11123
1982	24647	1,139,780	208444	2162	11824
1983	21111	1,166,324	223899	180	9428
1984	19522	1,265,100	239212	1543	8161
1985	20789	1,306,200	253229	1591	8210
1986	18330	1,304,700	247794	1405	7397
1987	17653	1,517,100	254539	1163	6935
1988	19479	1,587,100	271889	1227	7164
1989	16195	1,633,200	293582	992	5516
1990	15607	1,844,300	303284	846	5164
1991	15269	1,908,800	309539	799	4942
1992	17533	2,011,400	344850	872	5084
1993	17759	2,083,100	399480	853	4446
1994	19397	2,230,000	447867	870	4331
1995	18071	2,377,453	428149	760	4221

Table (2-A)
Regression Estimates of the Trends of the Rates of RTAs, RTA Fatalities and RTA Injuries in the UAE, between 1981-1995

Type of RTA Rate	Regression Coefficient	R^2	P. Value
RTA rate per 100,000 population	-96.6	0.884	0.000
RTA rate per 100,000 Vehicle	-522	0.902	0.000
RTA Fatality rate per 100,000 population	-1.1	0.586	0.02
RTA Fatality rate per 100,000 vehicle	-5.1	0.330	0.025
RTA Fatality rate per 1000 accident	1.132	0.608	0.000
RTA Injury per 100,000 population	-6.79	0.341	0.03
RTA Injury per 100,000 vehicles	-28	0.270	NS
RTA Injury rate per 1000 accident	25.43	0.838	0.000
Total Annual RTA Fatalities	12.9	0.341	0.02
Total Annual RTA Injuries	325	0.854	0.000
Total Annual RTAs	-337	0.440	0.007

Despite the persistent increase in the number of vehicles in the UAE throughout the period 1981-1995 (Table 1 and Fig. 3), the rate of RTAs per 100,000 registered vehicles continuously declined (Table 2; Fig. 4). In the first half of the 1980s the rate declined by 26%; between 1986 and 1990 the decline further steeped, falling by 37%; between 1991 and 1995 the rate declined more slowly by 14.6%. The overall rate of RTAs per 100,000 registered vehicles declined from 11,123 in 1981 to 4,221 only in 1995 (Table 2), equivalent to a 62% decline; or an annual average declining trend component of –522 ($p < .001$) (Table 2-A).

Fig. (1)
The UAE Population Growth Curve during the period 1981-1995

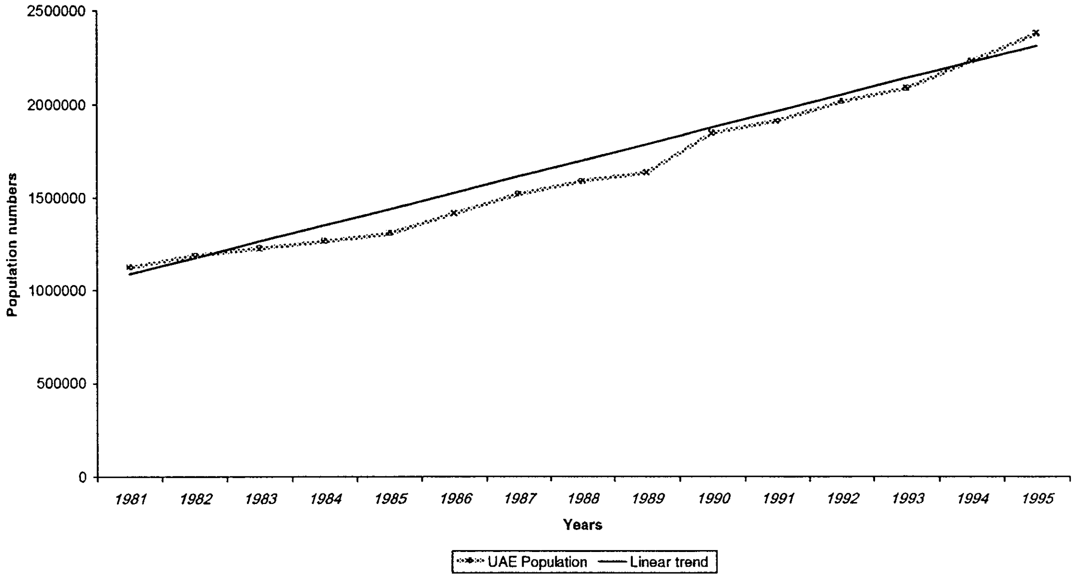


Fig. (2)
Trend of RTAs per 100,000 population in the UAE (1981-1998)

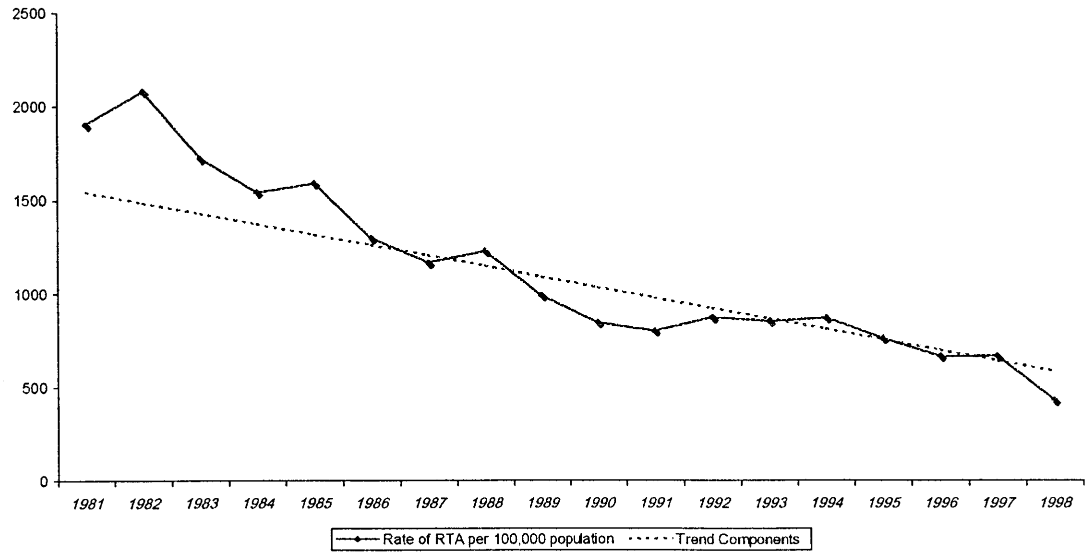
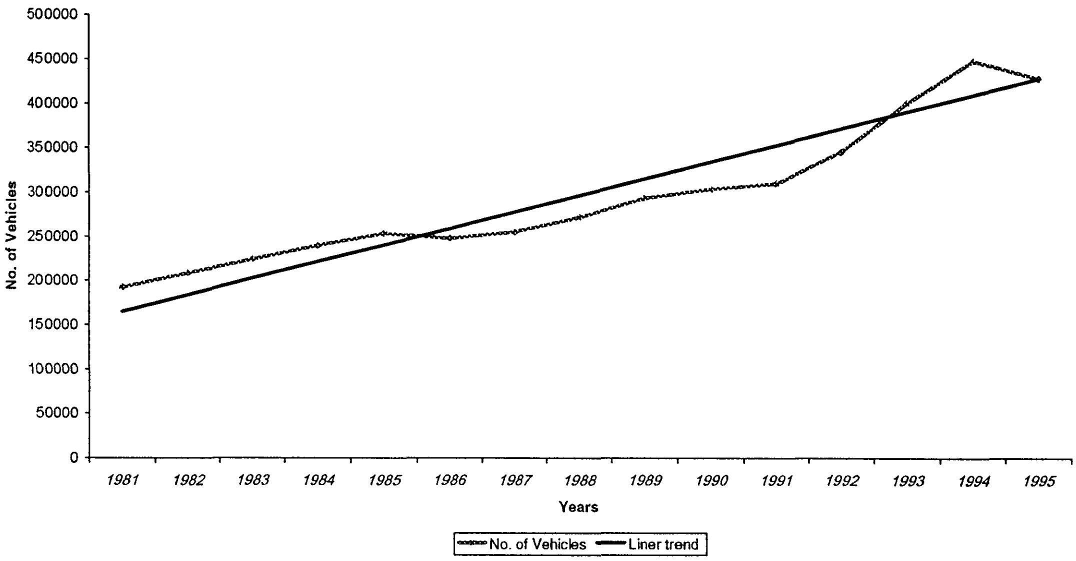


Fig. (3)
Growth of Registered Motor Vehicles in the UAE during 1981-1995



8.1.3 Trend of RTA Fatalities in UAE during 1981-1995

Between 1988 and 1994, RTAs became the second top cause of death in the UAE after cardiovascular diseases (CVD) (Table 3). In 1988 they accounted for 9.8% (336) of the total deaths in the UAE, and the percentage steadily increased to reach 13.1% (600) in 1994. Except for CVD and malignant neoplasm, the percentages of all other causes of death showed declining trends.

Time series analysis of RTA-specific fatality rates adjusted to resident population and number of registered motor vehicles showed that RTA fatality rates were declining during 1981-1995. The number of deaths from RTAs declined, during the first half of the 1980s from 460 deaths in 1981 to only 288 in 1985 (a 37.4% decline) (Column 2, Table 4). From 1986, however, they began to increase rapidly to reach 394 in 1990 (a 37% increase). During 1991-1995 the number increased substantially from 490 in 1991 to 563 cases in 1995 (a 42.9% increase). The trend analysis showed that during the study period 1981-1995, the number of RTA fatalities increased by a linear trend component of 12.9 (p=0.02) (Fig. 5).

Table (3)

The Leading Causes of Death in UAE (1988 - 1994)

Sr. No	**Reported Cause of Death**	**1988**		**1989**		**1990**		**1991**		**1992**		**1993**		**1994**	
		No.	%	*No.*	%	*No.*	%	*No.*	%	*No.*	%	*No.*	%	*No.*	%
1	Cardio Vascular Diseases	644	18.9	524	14.1	641	16.7	823	20.0	837	20.0	1069	24.8	1070	23.1
2	Road Traffic Injuries	**336**	**9.8**	**372**	**10.1**	**394**	**10.2**	**490**	**11.9**	**510**	**12.0**	**567**	**13.0**	**600**	**13.1**
3	Congenital Anomalies	223	6.5	200	5.4	164	4.3	236	5.8	227	5.3	226	5.3	250	5.8
4	Malignant Neoplasm	209	6.1	164	4.4	202	5.3	260	6.4	264	6.2	339	7.9	279	6.3
5	Respiratory Diseases	225	6.6	96	2.6	60	1.6	112	2.7	120	2.8	135	3.1	121	2.6
6	Infectious and Parasitic Diseases	53	1.6	73	2.0	37	1.0	32	0.8	44	1.0	43	1.0	51	1.1
7	Septicaemia	56	1.6	48	1.4	43	1.1	85	2.0	71	1.7	83	1.9	98	2.1
8	Complication of Deliveries and Prenatal	91	2.6	126	3.4	147	3.8	207	5.0	240	5.6	256	6.0	168	3.7
9	Digestive System Diseases	70	2.1	132	3.6	153	4.0	177	4.3	143	3.3	171	4.0	186	4.0
10	Urogential Diseases	70	2.1	58	1.6	66	1.7	102	2.4	113	2.5	122	2.8	107	2.4
11	Signs, Symptoms and Ill-Defined Conditions	--	----	717	19.4	764	20.0	1066	26.0	713	16.7	1074	25.1	655	14.3
12	Nero Sensory Diseases	56	1.6	24	0.6	36	1.0	37	0.9	24	0.6	48	1.1	27	0.6
13	Burns, Poisoning and Toxic effects	71	2.1	45	1.2	82	2.1	98	2.4	129	3.0	94	2.2	167	3.6
14	Homicide, suicide, accidental falls & other not stated accidents	88	2.6	87	2.4	105	2.7	165	4.0	97	2.3	--	---	133	2.9
15	Others	1221	35.8	1029	27.8	952	24.8	213	5.2	729	17.0	81	1.8	724	15.9
	Total	3413	100	3695	100	3845	100	4103	100	4271	100	4302	100	4597	100

Fig. (4)
Trend of RTAs in the UAE per 100,000 Motor Vehicles during
1981-1995

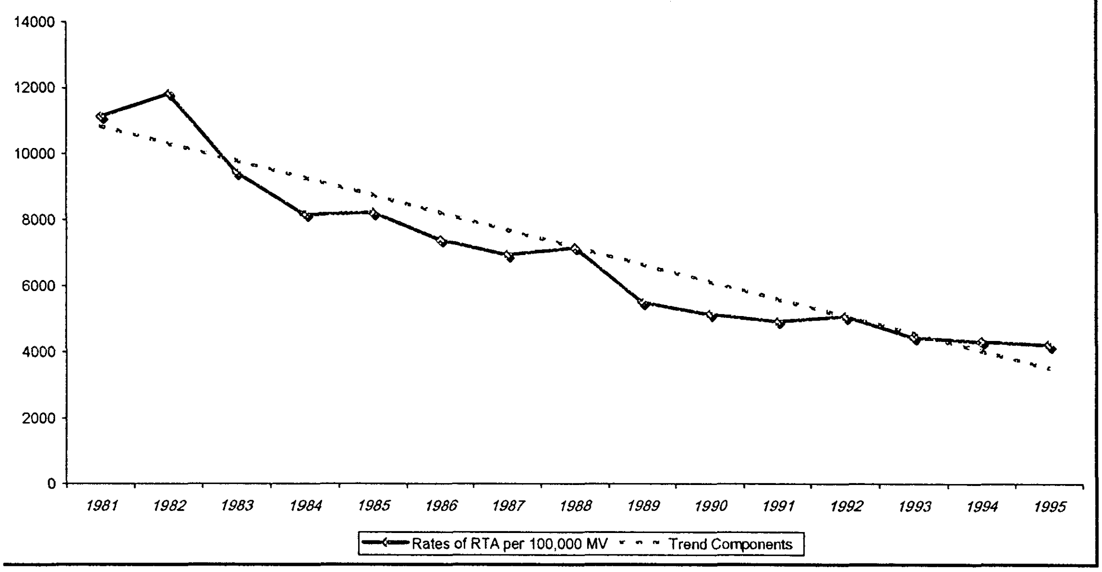
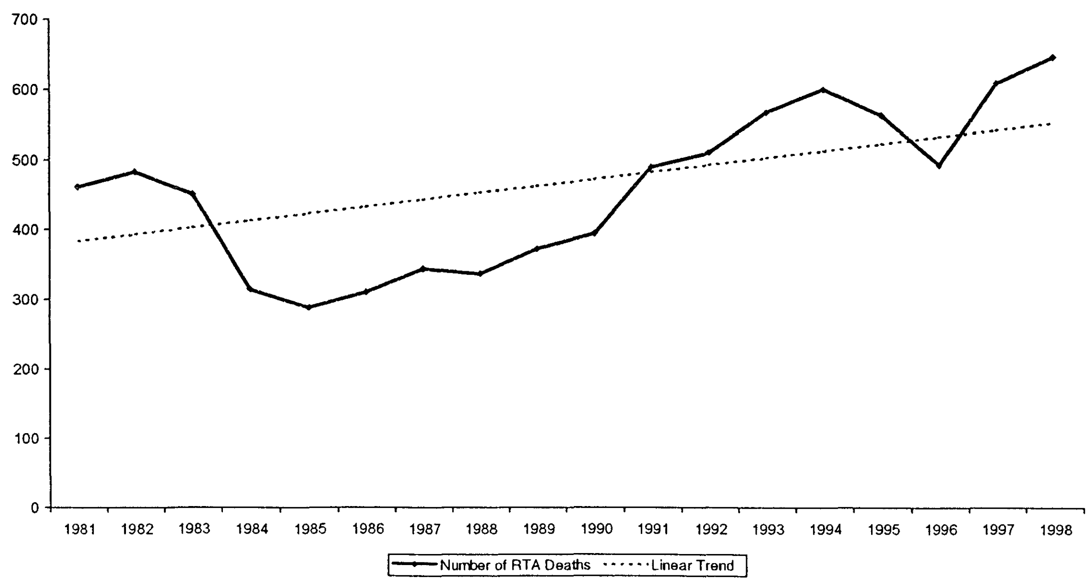


Fig. (5)
Trend of RTA Deaths in the UAE (1981-1998)



The RTA-specific fatality rate per 100,000 population (Column 3, Table 4) declined sharply from 41 in 1981 to 22 in 1985 (a 46% decline). The rate did not vary much between 1986-1990, the mean average rate being 22.4. From 1991 to 1994 the rate increased sharply to 27 before dropping to 24 in 1995 (Fig. 6). Over the whole period of 1981-1995, the overall rate of decline was 41.4%, equivalent to an average declining linear trend component of -1.1 ($p= 0.02$) (Table 2-A).

The RTA-specific fatality rate per 100,000 registered vehicles also declined sharply (Column 4, Table 4 and Fig. 7). Between 1981 and 1985, the rate declined from 240 to 114 (a 52.5% decline). During 1986-1990, however, the rate increased and fluctuated moderately, with a mean rate of 128.2. During 1991-1992 the rate increased sharply to reach 158 (a 21.5% increase) but it started to descend again from 1993 to reach 131 in 1995. The overall rate of decline during 1981-1995 was 45.4%, giving an annual average declining trend component of -5.1 ($p=.02$) (Table 2-A).

Fig. (6)
Trend of RTA Fatalities per 100,000 Population in the UAE during (1981-1995)

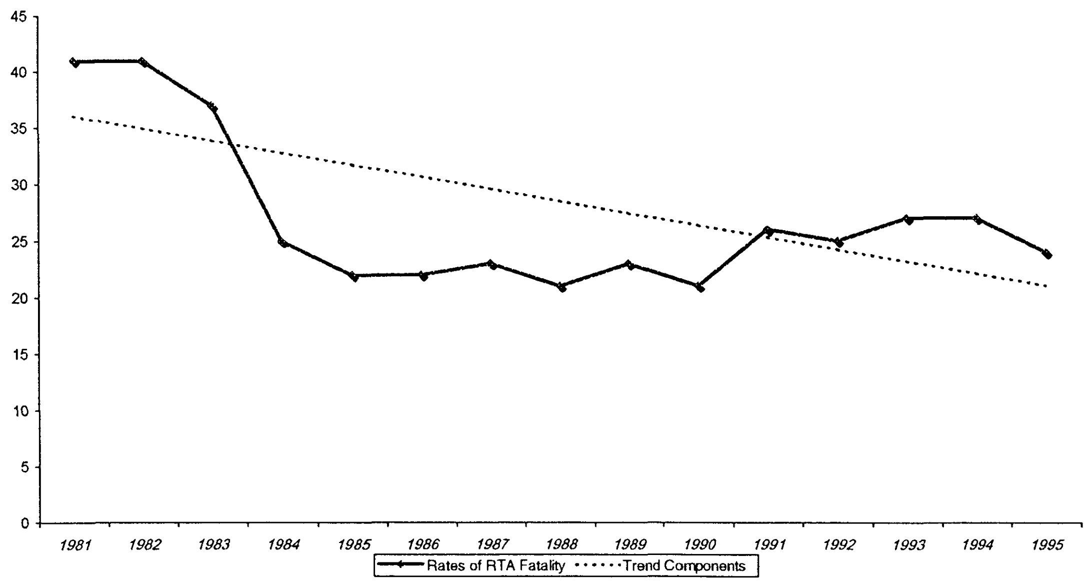
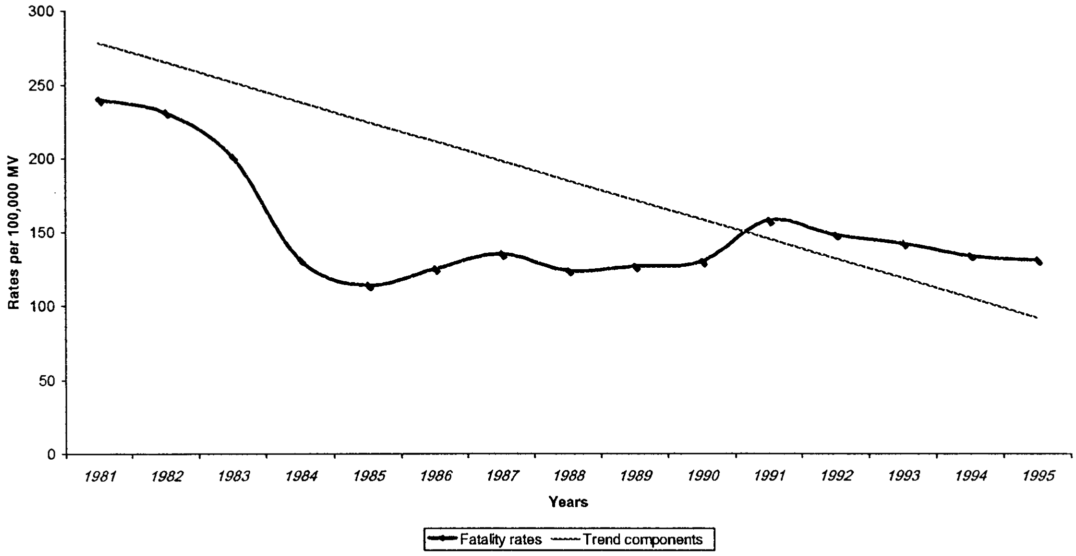


Table (4)
Rates of RTAs, RTA Fatalities and Injuries in the UAE
(1980-1995)

Year	RTA Fatality Rates				RTA Injury Rates			
	RTA Fatalities	per 100,000 resident population	per 100,000 registered motor-vehicles	per 1000 RTAs	RTA injuries	per 100,000 resident Population	per 100,000 registered motor-vehicles	per 1000 RTAs
1981	460	41	240	22	6214	553	3236	291
1982	482	41	231	20	6580	555	3157	267
1983	450	37	201	21	5717	467	2553	271
1984	314	25	131	16	5389	426	2253	276
1985	288	22	114	14	5601	429	2212	269
1986	310	22	125	17	6214	440	2508	339
1987	343	23	135	19	6394	421	2512	362
1988	336	21	124	17	7246	457	2665	372
1989	372	23	127	23	7889	483	2687	487
1990	394	21	130	25	8524	462	2811	546
1991	490	26	158	32	8695	456	2809	569
1992	510	25	148	29	9641	479	2796	550
1993	567	27	142	32	9817	471	2457	553
1994	600	27	134	31	9781	439	2184	504
1995	563	24	131	31	9820	413	2294	543

Fig. (7)
Trend of RTA Fatalities in the UAE per 100,000 Motor Vehicles
1981-1995



8.1.4 **Trend of RTA Injuries in the UAE during 1981-1995**

Despite their serious limitations, the data from available sources showed that, like RTA fatalities, the volume of injuries resulting from RTAs in the UAE as a whole were steadily increasing throughout the period 1984-1995 (Table 1 and Fig. 8). Apart from a short period of decline, from 1981 to 1984, the numbers of injuries were steadily increasing; the highest percentage increases were in 1988 and 1992. The cumulative percentage increase over the whole period was 49%, and the mean annual increase was 4%.

In the individual Emirates, the cumulative percentages of RTA injuries increased between 1981 and 1995 as follows: in Abu Dhabi Emirate (which includes Abu Dhabi, Al-Ain and Turaif districts) by 47.8%; in Dubai by 73.2%; in Sharjah by 83%; in Ajman by 88%; in Umm-Al-Quin by 28%; in Ras-Al-Khaima by 10%; and in Fujairah by 206%. The district of Turaif had the highest percentage increase in RTA injuries (a 220% increase) (Table 5).

Table 4 (columns 7 and 8) demonstrates the trend of RTA injury in the UAE during the period 1981-1995 adjusted by demographic factors including resident population and number of registered vehicles. The rate of RTA injuries per 100,000 population declined by 23.4% between 1981-1985. During the period 1986-1990 the rate fluctuated, but still declined by 2.9%. Between 1991 and 1995 it further declined by 9.4%.

Fig. (8)
Trend of RTA Injuries in the UAE during the period 1981-1995

Fig. (9)
Trend of RTA Injuries per 100,000 Population in the UAE
(1981-1995)

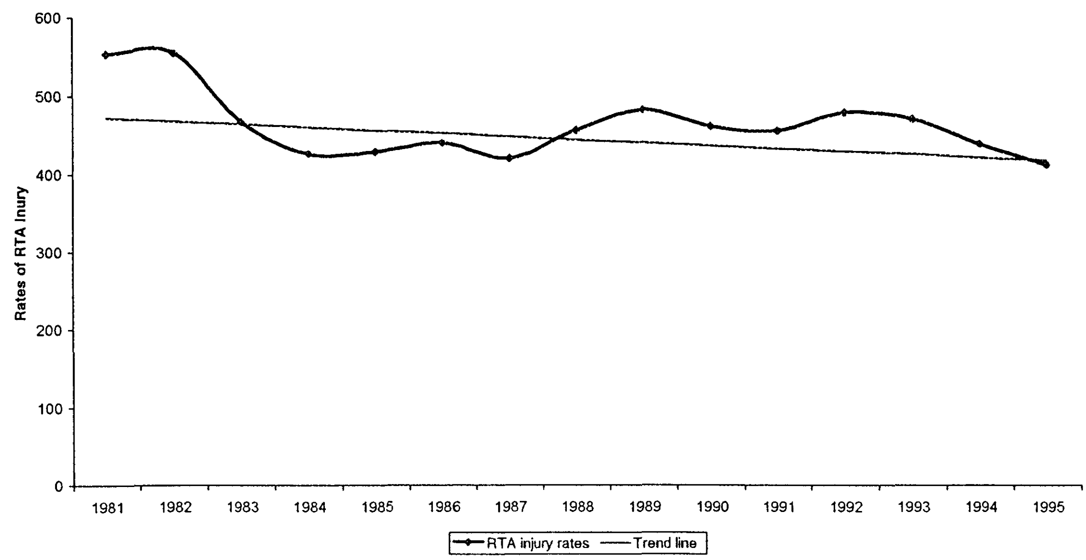


Table (5)

Nonfatal Traffic Injuries in the UAE by Districts
(1981-1995)

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Abu Dhabi	2110	2008	1443	1215	1359	1604	1646	2048	2349	2542	2565	2970	2960	2982	3072
Al-Ain	779	750	719	617	583	602	604	600	533	594	644	778	782	929	858
Turaif	144	206	162	146	251	224	332	352	362	357	479	472	462	583	553
Dubai	1669	1886	1924	1915	1778	2129	2039	2269	2621	2887	2840	3153	3096	2830	2891
Sharjah	460	465	320	428	479	588	735	549	462	719	698	797	858	778	844
Ajman	199	274	232	1224	227	186	227	320	314	242	311	274	361	403	375
Umm-Alquin	111	134	112	130	115	90	113	169	255	212	190	199	150	79	142
Ras-Alkhima	646	733	678	569	6281	630	646	762	712	767	754	781	883	857	709
Fujairah	123	124	127	145	181	161	166	177	181	204	214	217	265	340	376
Total	6241	6580	5717	5389	5601	6214	6394	7246	7889	8524	8695	9641	9817	9781	9820
% Change Over Years	**-**	**+5.4**	**-8.4**	**-13.7**	**-10.3**	**- 0.4**	**+2.5**	**+6**	**+26**	**+37**	**+39**	**+54**	**+57**	**-0.4**	**+0.4**

Although the numbers of injuries increased by 58% between 1981 and 1995 (column 6, Table 1) the overall rate of RTA injuries, adjusted by the UAE resident population, fell by more than 26% (Fig. 9), giving a linear declining trend component of -6.8 (p=.03) (Table 2-A). Between 1981 and 1995, the injury rate per 100,000 registered motor vehicles fell by 29.4% (Table 4: Column 8; Fig. 10). In the first half of the 1980s the rate declined by 32%, but it increased by 12% towards the end of the 1980s before dropping again by 18.4% between 1991-1995.

8.1.5 **The Risk of Injury and Death in RTAs in the UAE**

Contrary to the trends shown above, the fatality and injury rates per 1000 RTAs did not show prolonged negative trends during the period 1981-1995 (Fig. 11 and Fig.12). During the period 1981-1995 the fatality rate per 1000 RTA increased by 47.6%; with an increasing linear trend component of 1.13 (p<.001). Although, the rate decreased at first from 21 in 1981 to 14 in 1985, (Table 4, Column 5), thereafter it increased until it reached 25 in 1990. In 1991 it further increased to 32; but in 1994 and 1995 it fell slightly to 31.

The injury rate per 1000 RTAs resembled the fatality rate (Table 4, Column 9). The overall increase during 1981-1995 was 86%; equivalent to an annual average linear trend component of 25.4 (p<.001) (Table 2-A). At first, the rate declined by 8% until 1985 but it increased by 61% by 1990, fluctuating and declining slightly until 1995.

In conclusion, the overall rate of RTA injuries per 1000 accidents was found increasing throughout 1981-1995 except during the first half of the 1990s.

Fig. (10)
Trend of Injuries from RTAs per 100,000 Motor Vehicles
1980-1995

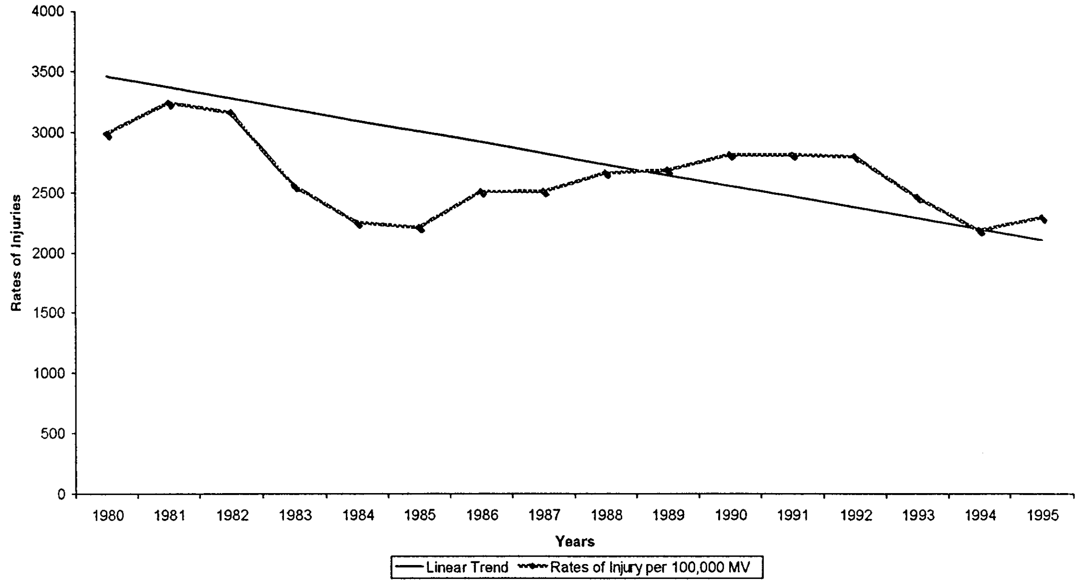


Fig. (11)
Trend of Mortality from RTAs per 1000 RTA in the UAE
(1985-1998)

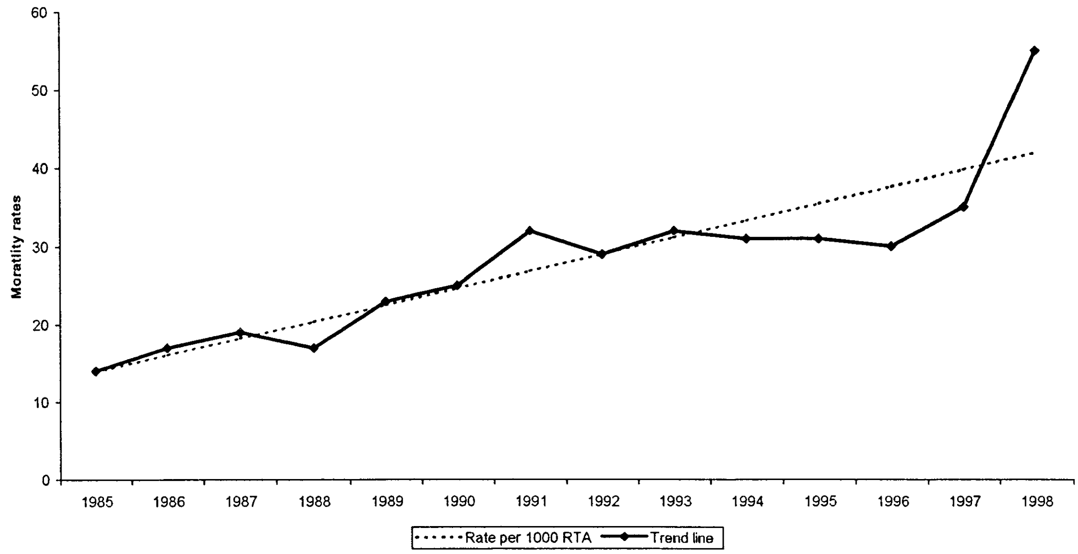
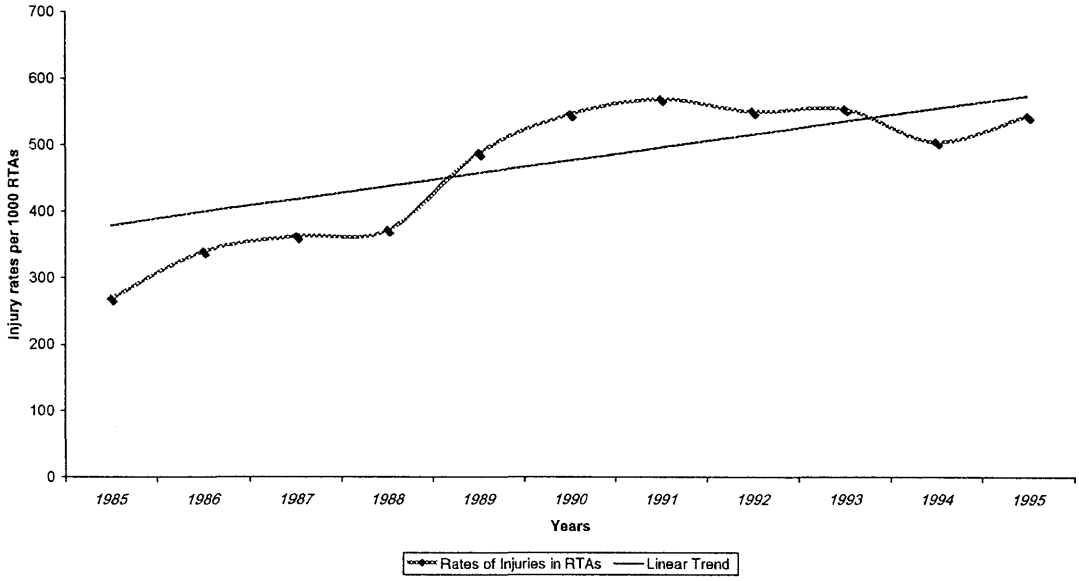


Fig. (12)
Trend of Injuries per 1000 RTAs in the UAE during (1985-1995)



8.1.6 Alleged Causal Factors of RTAs in the UAE during 1990 - 1995

As mentioned before, the official police reports, the main source of data for this study, were generally organised for purposes of security and legal prosecution. As such, they were rarely comprehensive to provide an adequate database for epidemiological analysis, especially when addressing the causes of RTAs. In addition to that, these reports lacked consistency in classification and tabulation of data, especially for the reports dating back to the 1980s.

For these reasons, only the data covering the period 1990-1995, which was more or less consistent in classification and relatively richer in information relating to RTAs causal factors, were used in this analysis. Table (6) shows the causal factors of RTAs according to police classification. Virtually no major changes were seen in the pattern of alleged causal factors contributing to RTAs in the UAE during the period 1990-1995. Careless driving, according to police , includes lack of attention and undertaking of serious traffic risk, was the largest component, contributing to 50% of RTAs and remained constant throughout the study period (Table 6).

Table (6)

Causal Factors of Fatal and Non-Fatal RTAs in the UAE, 1990 - 1995

Year	Careless Driving	Personal Factors	Excessive Speed	Alcohol	Vehicle's Condition	Environmental Factors	Roadway Condition	Other Conditions	Total
1990	7488 *48%*	4768 *30.6%*	2530 *16.2%*	370 *2.4%*	283 *1.8%*	83 *0.5%*	35 *0.2%*	50 *0.3%*	15607 *100%*
1991	7400 *48.3%*	4509 *29.4*	2535 *16.6%*	303 *2%*	274 *1.8%*	97 *0.6%*	143 *1%*	54 *0.4%*	15315 *100%*
1992	8188 *49.4%*	4520 *27.2*	2951 *17.8%*	329 *2%*	218 *1.3%*	220 *1.3%*	75 *0.5%*	76 *0.5%*	16577 *100%*
1993	9495 *53.4%*	4340 *24.4%*	3239 *18.2%*	301 *1.7%*	288 *1.6%*	67 *0.4%*	21 *0.1%*	18 *0.1%*	17805 *100%*
1994	9986 *51.5%*	5010 *25.8%*	3280 *17%*	326 *1.7%*	340 *1.8%*	205 *1%*	83 *0.4%*	167 *0.8%*	19397 *100%*
1995	8772 *48.5%*	5269 *29.2%*	2279 *12.6%*	322 *1.8%*	196 *1.4%*	153 *0.8%*	51 *0.4%*	436 *3.1%*	18071 *100%*

Personal factors, according to police sources, include all non-specific causal factors which influence the drivers' ability to judge traffic risk, such as: age, urbanisation, hearing, vision, fatigue, training and education of drivers, psychological stability, intelligence, personality, social maturity and risk-taking behaviour. The aggregate effect of these personal factors, the second major cause of RTAs in UAE (column 3, Table 6) in effect declined slightly until 1993 before rising again in 1995. Excessive-speed, the third cause of accidents in the UAE, rose slightly between 1990 and 1993 but had fallen again by a third by 1995 (column 4, Table 6). The effect of environmental factors remained more or less constant, contributing between 0.2% to 1.3% (Column 7, Table 6). The effect of vehicle conditions also remained constant with a proportion varying from 1.3% to 1.8% (Column 6, Table 6). Alcohol contributed a smaller effect compared to the other causes of RTAs in UAE probably due to the religious and legal restrictions over it in an Islamic society. Its proportion steadily declined from 2.4% in 1990 to 1.8% in 1995 (column 5, Table 6). There was an increase in the category labelled "other factors" (column 9, Table 6).

Tables 7 and 8, present causes of RTAs contrasted by types of RTAs (i.e. collision, pedestrian or turnover) and the resultant injuries and fatalities for two selected years; 1990 and 1995. In both years, as can be seen from the tables, careless driving was the major causal factor for RTAs, being responsible for almost 50% of total collisions, turnovers and total pedestrian crashes. Also, it was the preponderant factor for RTA deaths and injuries in both years (a percentage of 38% of total fatalities in 1990 compared to 36% in 1995; and a percentage of 46% of total injuries in 1990 compared to 43% in 1995). The total effect of excessive-speed though fell down from 16% in 1990 to 13% in 1995, yet remained a major factor for RTA deaths and injuries. As can be seen on both tables, excessive-speed had lesser effect on collisions and pedestrian crashes in 1995 compared to 1990 (4% decline for collisions and 11% decline for pedestrians) but higher effect on turnovers, where the proportion increased from 22.5% to 30%.

The effect of excessive-speed, though had declined from 32% to 27% for deaths and from 17% to 13% for injuries in both years respectively, yet remained a major causal factor responsible for over one quarter of total deaths and one eighth of total injuries in 1995. It was also responsible for 30% of total turnovers in 1995 compared to 23% in 1995. The collective effect of personal factors on RTAs declined from 31% in 1990 to 29% in 1995. The resultant fatalities and injuries due to personal factors declined as well from 20% to 16% for fatalities and from 30% to 26% for injuries between the two years respectively.

Alcohol though was responsible for 2.4% and 1.8% of total RTAs in 1990 and 1995 respectively, resulted in higher proportion of fatalities and injuries in both years (4.2% of fatalities and 2% of injuries in 1990; and 3% of fatalities and 1% of injuries in 1995). Vehicle conditions had a major effect on RTAs collisions, being responsible for 14% and 10% of turnover accidents in the two years respectively.

Table (7)

Types and Causes of RTAs in the UAE during 1990

RTA Types / **RTA Causes**	**Collision**	**Turnover**	**Pedestrian**	**Total**	**Fatalities**	**Injuries**
Careless driving	5758 48.6%	718 47%	1017 45.6%	7488 48%	149 37.8%	3976 46.4%
Speeding	1713 14.5%	344 22.5%	473 21%	2530 16.2%	126 32%	1487 17.4%
Alcohol	309 2.6%	49 3.2%	12 0.5%	370 2.4%	18 4.6%	159 1.9%
Environmental Factors	27 0.3%	7 0.5%	5 0.2%	83 0.5%	-	45 0.5%
Personal Factors	3828 32.3%	219 14.4%	721 32.3%	4768 30.5%	81 20.6%	2586 30.3%
Vehicle condition	118 1%	165 10.8%	-	283 1.8%	18 4.6%	265 3.1%
Act of God	46 0.4%	3 0.2%	3 00.1%	50 0.3%	2 0.5%	7 0.1%
Roadway factors	55 0.5%	1 -	1 -	35 0.2%	-	9 0.1%
Total	11,849 100%	1,526 100%	2,232 100%	15,607 100%	394 100%	8,534 100%

Table (8)

Types and Causes of RTAs in the UAE during 1995

RTA Types / RTA Causes	Collision	Turnover	Pedestrian	Total	Fatalities	Injuries
Careless driving	6918 49.7%	930 47%	924 42.2%	8772 48.5%	204 36.2%	4137 42.5%
Speeding	1468 10.5%	580 29.5%	231 10.6%	2279 12.6	150 26.6%	1264 12.9%
Alcohol	263 2%	44 2.2%	15 0.7%	322 1.8%	17 3.1%%	116 1.2%
Environmental Factors	131 0.9%	21 1%	1 0.1%%	153 0.8%	2 0.4%	30 0.3%
Personal Factors	4456 32%	199 10.1%	614 28%	5269 29.2%	91 16.2%	2527 25.7%
Vehicle condition	196 1.4%	148 7.5%	2 0.1%	346 2%	3 0.5%	181 1.8%%
Act of God	45 0.3%	5 0.3%	149 6.8%	199 1%	3 0.5%	96 1%
Roadway factors	51 0.4%	20 1%	16 0.8%	87 0.5%	1 0.2%	34 0.3%
Other Factors	391 2.8%	18 0.9%	235 10.7%	644 3.6%	92 16.3%	1435 14.6%
Total	13,919 100%	1965 100%	2187 100%	28,071 100%	563 100%	9,820 100%

When the types of accidents were examined for the years 1981-1995, vehicle-to-vehicle collision remained overwhelmingly the major type of RTAs, been the cause for over 75% in all years (Table 9). Though the numbers of annual total vehicle-to-vehicle collisions declined by around 15% between 1981 and 1995, their proportion relative to other types of accidents remained unchanged. The proportion of accidents caused by vehicle-turnovers declined from 15% in 1981 to 11% only in 1995. However, the proportion of vehicle-pedestrian crashes increased from 9% in 1981 to 12% in 1995 and the numbers also increased.

8.1.7 Demographic Characteristics of RTA Victims in the UAE

The analysis of total RTA fatalities and injuries by age during 1983-1995 revealed that those mostly affected by RTAs injuries and fatalities were individuals in the middle age group of 21-30 years followed by those on the age group of 31-40 years (Table 10). A massive proportion of 69% of total RTAs, 57% of total RTA deaths and 56% of total RTA injuries were among individuals in these two age groups. The age groups above 40 years sustained less than 15% of total accidents, 13% of total RTA injuries and 17% of total RTA deaths; while the age group below 11 years sustained a proportion of 1% of total RTAs, 13% of total RTA injuries and 13% of total RTA deaths. Vehicle- vehicle collisions were the major accident type among the middle age groups.

Table (9)
Distribution of RTAs in UAE according to Types of Accidents, Number of Injuries and Fatalities (1981-1995)

	Types of Accidents				**Total**	
Year	*Collision*	*Turnover*	*Pedestrian*	*Total*	*Fatalities*	*Injuries*
1981	16,313	3,202	1,844	21,360	460	6,241
%	*76%*	*15%*	*9%*	*100%*		
1982	19,274	3,479	1,894	24,647	482	6,580
%	*78%*	*14%*	*8%*	*100%*		
1983	16,618	2,769	1,724	21,110	450	5,717
%	*79%*	*13%*	*8%*	*100%*		
1984	15,615	2,257	1,650	19,522	314	5,389
%	*80%*	*12%*	*8%*	*100%*		
1985	16,681	2,409	1,699	20,789	288	5,601
%	*80%*	*12%*	*8%*	*100%*		
1986	14,111	2,469	1,750	18,330	310	6,214
%	*77%*	*13%*	*10%*	*100%*		
1987	13,404	2,368	1,881	17,653	343	6,394
%	*76%*	*13%*	*11%*	*100%*		
1988	15,713	1,665	2,101	19,479	336	7,246
%	*81%*	*9%*	*10%*	*100%*		
1989	12,520	1,552	2,123	16,195	372	7,889
%	*77%*	*10%*	*13%*	*100%*		
1990	11,849	1,526	2,232	15,607	394	8,524
%	*76%*	*10%*	*14%*	*100%*		
1991	11,557	1,582	2,157	15,296	490	8,695
%	*76%*	*10%*	*14%*	*100%*		
1992	13,681	1,691	2,156	17,533	510	9,641
%	*78%*	*10%*	*12%*	*100%*		
1993	13,701	1,862	2,196	17,759	567	9,817
%	*77%*	*10%*	*13%*	*100%*		
1994	15,128	1,994	2,275	19,397	600	9,781
%	*78%*	*10%*	*12%*	*100%*		
1995	13,919	1,965	2,187	18,071	563	9,820
%	*77%*	*11%*	*12%*	*100%*		

The individuals of these two groups engaged in about 69% of vehicle-to-vehicle crashes, 70% of turnovers and 68% of vehicle-pedestrian crashes. Thus there was no particular type of accident to which they were not prone.

The UAE Police reports do not classify RTA casualties by sex. To overcome this limitation a four year data on RTA fatalities, classified by sex and age for the years 1992-1995, published in the recent MoH annual reports was used to give an insight of RTA trends according to sex. The analysis of that data revealed that males accounted for an average of 85% RTA deaths and females for 15%; most were in the middles age groups (15-44 years) for both sexes (Table 11). This finding confirmed that most of RTA deaths in the UAE were among males, especially the productive age group (15-44).

Table (10)
Distribution of RTAs according to the Age Group (1983-1995)

Age Groups (Years)	**Types of Accidents**			**Total Accidents**	**Total Injuries**	**Total Deaths**
	Collision	**Fail vehicles**	**Pedestrian**			
Less than 11	1793 *1%*	447 *2%*	266 *1%*	2497 *1%*	12502 *13%*	627 *13%*
11 - 20	26976 *16%*	4399 *16%*	3795 *17%*	35385 *16%*	16126 *17%*	694 *14%*
21-30	71449 *42%*	11158 *42%*	8875 *41%*	91043 *41%*	31930 *34%*	1618 *33%*
31-40	47318 *27%*	7388 *28%*	5867 *27%*	61036 *28%*	21534 *23%*	1123 *23%*
more than 40	24394 *14%*	3439 *12%*	2983 *14%*	30872 *14%*	12520 *13%*	836 *17%*
Total	171630 *100%*	26831 *100%*	21786 100%	220,833 *100%*	94612 *100%*	4898 *100%*

Table (11)
Distribution of RTA Fatalities by Sex and Age Group
1992-1995

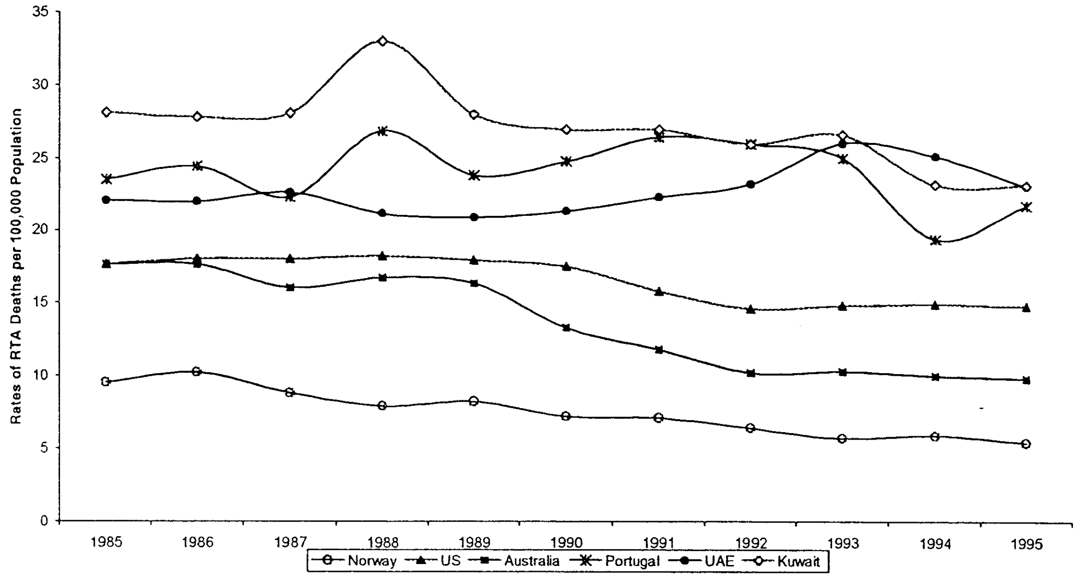
Year	*Sex* (*F/M*)	**Age Group** *(Years)*							**Total** *(all ages)*	*%* *(M/F)*
		0 - 1	**1 - 4**	**5-14**	**15-44**	**45-59**	**60+**	**N.S.**		
1992	***M***	3	20	21	242	48	14	49	397	(85%)
	F	1	11	15	27	7	5	4	70	(15%)
	Total	4	31	36	269	55	19	53	**463***	100%
1993	***M***	2	23	25	329	62	16	17	474	(85%)
	F	1	13	14	42	5	4	8	87	(15%)
	Total	3	36	39	371	67	20	25	**561****	100%
1994	***M***	1	16	23	350	74	18	16	498	(89%)
	F	1	7	11	35	2	5	2	63	(11%)
	Total	2	23	34	385	76	23	18	**561*****	100%
1995	***M***	3	14	26	339	59	22	19	482	(88%)
	F	2	6	8	36	12	2	2	68	(12%)
	Total	5	29	34	375	71	24	21	**550******	100%

* Total RTA deaths according to MoH reports (less by 47 cases compared to police reports).
** Total RTA deaths according to MoH reports (less by 6 cases compared to police reports).
*** Total RTA deaths according to MoH reports (less by 39 cases compared to police reports).
**** Total RTA deaths according to MoH reports (less by 13 cases compared to police reports).

8.1.8 Comparative RTA Statistics

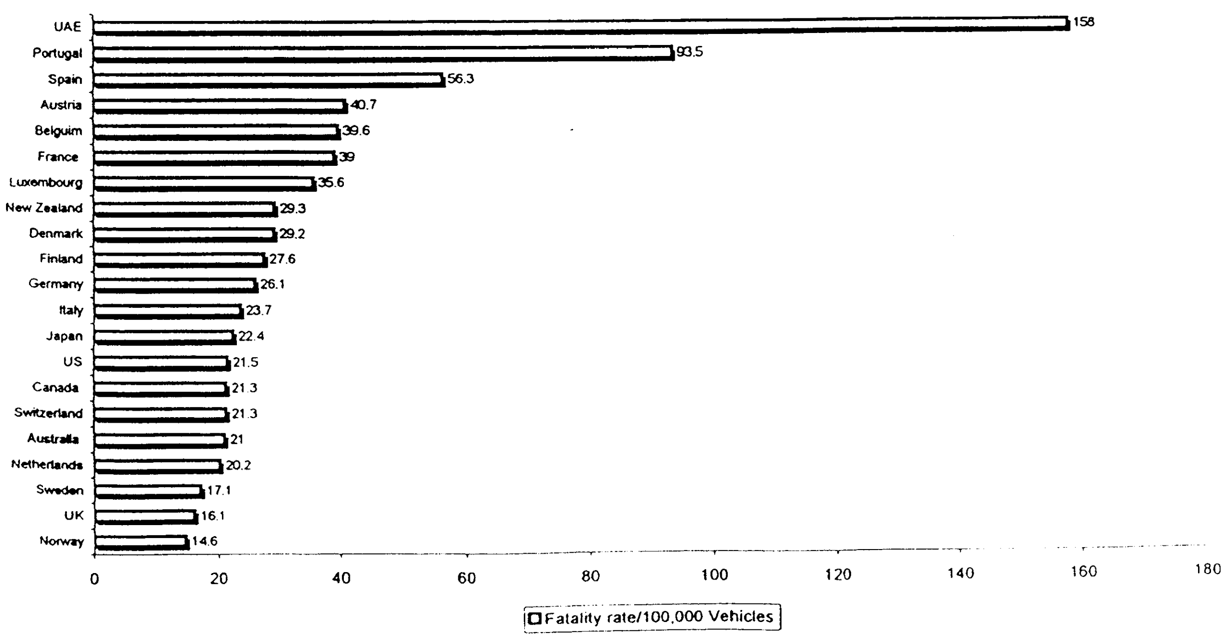
When the UAE's mortality rates from RTAs for the period 1985-1995 were compared with the equivalent rates in a number of developed and developing countries including Portugal, Norway, the USA, Australia and Kuwait, RTAs presented clearly a grave public health problem in the UAE (Fig. 13). Contrary to the declining RTA mortality trends in these countries the UAE showed an increasing trend, especially towards the middle of the 1990s (Fig.13). For the rate based on population, the UAE's rate was among the highest of those countries except for Kuwait and Portugal.

Fig. (13)
Trends in Mortality from RTAs for the UAE and some selected Countries
(1985-1995)



The UAE showed considerably higher rates, compared to the rates in developed countries except Portugal, which had over twice motor vehicle density than the UAE. The Personal Risk rate in the UAE in 1991 was almost twice the mean rate of developed countries, while the RTA risk rate was more than 5 times the mean rate in those countries, despite the fact that motor vehicle-density in the UAE was below 30% of the mean motor-vehicle density in those countries (Figure 14).

Fig. (14)
RTA Fatality Rates by Registered Motor Vehicles in20 Developed Countries
compared with the UAE's Rates in1991



8.2 Future Forecasts of RTA Fatalities in the UAE

8.2.1 Model Estimation: Fitting Smeed's Model

Firstly, the study attempted to fit the UAE fatality data during the period 1980-1998 using Smeed's formula. The results are shown on Table (12). The results revealed that RTA fatality estimates based on the formula were 32% lesser than the observed deaths. This is similar to the previous findings of Hampson in New South Wales in Australia (1982) and Jadaan in his study of a number of countries in the Arabian Gulf and some Middle Eastern countries (1988). These results demonstrate that the Smeed's model, which relates only the variables of vehicles, population and deaths cannot be applied universally to predict RTA fatalities. It is generally believed by researchers working in this field that the quality of data available during the 1940s, when the model was first suggested and applied, was not of sufficiently high precision to allow the derivation of a universal model (Bener, 1990, Jadaan, 1991).

8.2.2 The UAE Model Estimation

The results of our UAE model are presented in table (13). The model excluded factors of disposable income, careless driving speedy driving and number of motor vehicles due to low level of correlation between those variables and the dependent variable (Y_i). The summary statistics indicate that the model explained RTA fatalities in the UAE very well with an overall significance of (p=0.001) and R^2 (99.5%) and adjusted R^2 (98.7%).

The analysis shows that drivers of the age range 18-40 years have a significant positive impact (p<0.001) on RTA fatalities; a fact, which suggests an underlying problem associated with drivers from this age range. It is likely that speedy driving, lack of adequate training and failure to apply safety seatbelts by drivers from this age range are among those factors, as has been demonstrated by others (Bener, 1990; Jadaan, 1991). The coefficient for population had a significant positive sign (p=0.006). The result confirms the fact that as population increases RTA fatalities also tend to increase. The coefficient for GDP had a negative sign indicating that with higher GDP the higher the expenditure on roadway infrastructure causing roadway safety to increase as well. The result indicates that a 10% increase in GDP will lead to a 3.1% decrease in RTA deaths, though; it is equally possible that such an increase would be offset by other contributing factors, such as speedy driving.

Table (12)

Comparison of observed RTA Fatalities with Expected Fatalities estimated Using Smeed's Model

Year	Resident Population	Number of Registered Motor Vehicles	Actual RTA fatalities in the UAE	Estimates of fatalities from Smeed's formula*	Absolute Error using Smeed's equation	% error
1980	1,042,190	176,409	372	173	-199	53.4%
1981	1,110,300	192,031	460	185	-275	59.8%
1982	1,139,780	208,444	482	198	-284	58.9%
1983	1,166,324	223,899	450	210	-240	53.3%
1984	1,265,100	239,212	314	223	-91	28.9%
1985	1,306,200	253,229	288	235	-53	18.4%
1986	1,304,700	247,794	310	243	-67	21.6%
1987	1,517,100	254,539	343	254	-89	25.9%
1988	1,587,100	271,889	336	270	-66	19.6%
1989	1,633,200	293,582	372	288	-84	22.6%
1990	1,844,300	303,284	394	303	-91	23.1%
1991	1,908,800	309,539	490	312	-178	36.3%
1992	2,011,400	344,850	510	335	-175	34.3%
1993	2,083,100	399,480	567	360	-207	36.5%
1994	2,230,000	447,867	600	390	-210	35.0%
1995	2,377,453	428,149	563	400	-163	28.9%
1996	2,443,000	453,291	492	417	-75	15.2%
1997	2,624,000	440,878	609	433	-176	28.9%
1998	2,759,000	539,407	646	480	-166	25.7%
Average error						33.00%

* The following Smeed's formula was used to estimate RTA fatalities in UAE:

$D = 0.0003\ (PN^2)^{0..333}$

Table (13)
Regression Estimates of RTA Fatalities in the UAE
(1985-1998)

I. **ANOVA**

	Sum of Squares	df	Mean square	F-value	prob>F
Model	47635.718	5	9527.144	126.557	.001
Residual	225.838	3	75.279		
Total	47861.556	8			

$R^2 = 0.995$

II. **COEFFICIENTS:**

Variable	Unstandardised Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
	B	*Std. Error*	*Beta*		*P*	*Lower Bound*	*Upper Bound*
Intercept	57.976	37.436		1.549	.219	-61.164	177.115
Annual GDP	-0.00377	.001	-1.106	-7.318	.005	-.005	-.002
Mileage driven in the UAE	-0.02817	.006	-.877	-4.498	.021	-.048	-.008
drivers 18-30 yrs	1.011	.142	.954	7.147	.006	.561	1.462
UAE Population	+0.000483	.000	2.000	6.952	.006	.000	.001

Table (3) shows the prediction of RTA fatalities applying our multiple regression model. It can be seen that the prediction error of the model is below 0.05, or (5%). Therefore, it could be concluded that the model fits very well the UAE data, and the model equation is given by the following formula:

$$Y_i = 57.976 + 1.011\chi_4 + 0.000483\chi_1 - 0.00377\chi_5 - 0.02817\chi_2 \qquad (4)$$

Since the variable of speedy driving is not significant in the ANOVA test, the equation can be reduced to the following formula:

$$Y_i = 57.976 + 1.011\chi_4 + 0.000483\chi_1 - 0.02817\chi_2 \qquad (5)$$

Equation (5) can be used to estimate future RTA fatalities in the UAE with a coefficient of determination $(R^2) = 98\%$.

Table (14)

Annual Distribution of RTA Deaths, Population, Registered Vehicles, GDP, Disposable Income, Kilometres travelled, Drivers killed < age 30, or Careless and speedy driving and model's prediction (1977-1998)

Year	**Observed deaths**	Pop.	Vehicle s	GDP	Disp. income	Klm driven	Drivers < 30 years	Careless driving	Speedy driving	**Predicted deaths**	% error of prediction
1980	372	1042190	176409	111470	91576	3880	291	0	0	374	0.5
1981	460	1110300	192031	124050	99240	5801	332	0	0	428	7.0
1982	482	1139780	208444	115654	93679	5211	347	0	0	448	7.0
1983	450	1166324	223899	105504	85460	5597	381	0	0	492	9.0
1984	314	1265100	239212	104543	84670	5980	260	0	0	342	9.0
1985	288	1306200	253229	101990	81777	6330	219	0	0	291	0.5
1986	310	1304700	247794	81832	65046	6495	252	0	0	333	7.0
1987	343	1517100	254539	89218	70405	6565	251	0	0	338	1.5
1988	336	1587100	271889	88801	69111	6797	259	0	0	350	4.0
1989	372	1633200	293582	102549	80272	7340	257	0	0	349	6.0
1990	394	1844300	303284	125266	89675	7582	249	149	126	401	0.5
1991	490	1908800	309539	126264	88079	7738	322	145	138	487	4.0
1992	510	2011400	344850	131676	105974	8621	340	191	149	499	5.8
1993	567	2083100	399480	130972	102784	9987	431	291	169	572	0.5
1994	600	2230000	447867	134813	105243	11086	444	326	183	599	4.7
1995	563	2377453	428149	156902	140060	12708	434	204	150	561	8.3
1996	492	2443000	453291	175778	154373	11332	384	292	172	489	5.0
1997	609	2624000	440878	180630	155457	11903	461	281	181	612	.05
1998	646	2759000	539407	170066	143793	14833	453	297	160	646	2.0

8.2.3 **Model Estimation: A Summary**

Smeed's model, which has long been used as predictive tool for analysing the future trends of mortality from RTAs, using the numbers of population and motor vehicles, was found imperfect to predict RTA mortality in the UAE, where it produced a prediction error exceeding 30%.

A multiple regression model has been developed, using stepwise regression with backward iteration method. In addition to the factors of population and motor vehicles, used in Smeed's formula, the model attempted to incorporate other factors that are believed to optimise the final equation, and therefore, to produce better fit and prediction power. The factors of motor vehicles' kilometres driven, excessive speed, drivers' aged < 30 years when killed in RTAs, UAE annual disposable income and GDP were added to the equation using stepwise method with backward iteration. ANOVA was used to test the overall significance of the model and the t-test was used to test the significance of individual parameters. Better results were obtained when the model was applied to the UAE data during the period 1980-1998. The model gave an average percentage error <. 05.

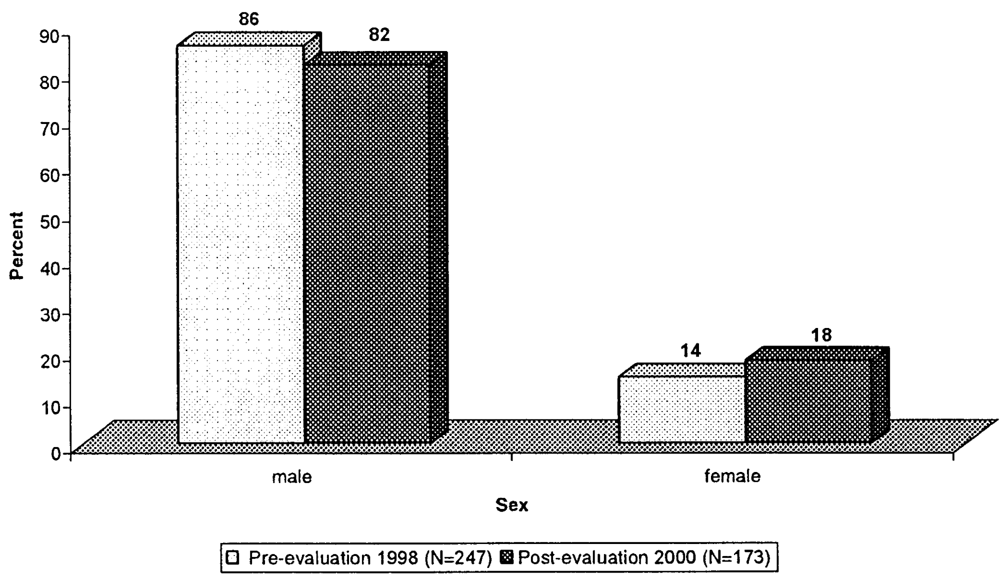
In conclusion, the analysis revealed that drivers on the age group 18-40 years have the highest impact on RTA fatalities in the UAE. This reflects an underlying problem, most likely associated with driving behaviours of individuals from this age group. It is likely that speedy driving, lack of adequate training and failure to apply safety seatbelts by youngsters and new drivers are among those factors, as has been suggested by many authors before. Thus, future trends of RTA mortality and morbidity as well are most likely to rely upon the existence or absence of improvements in the aforementioned areas.

8.3 Evaluation of Effectiveness of Seatbelt Legislation

8.3.1 RTA Injury Severity Assessment in the Pre-evaluation Period

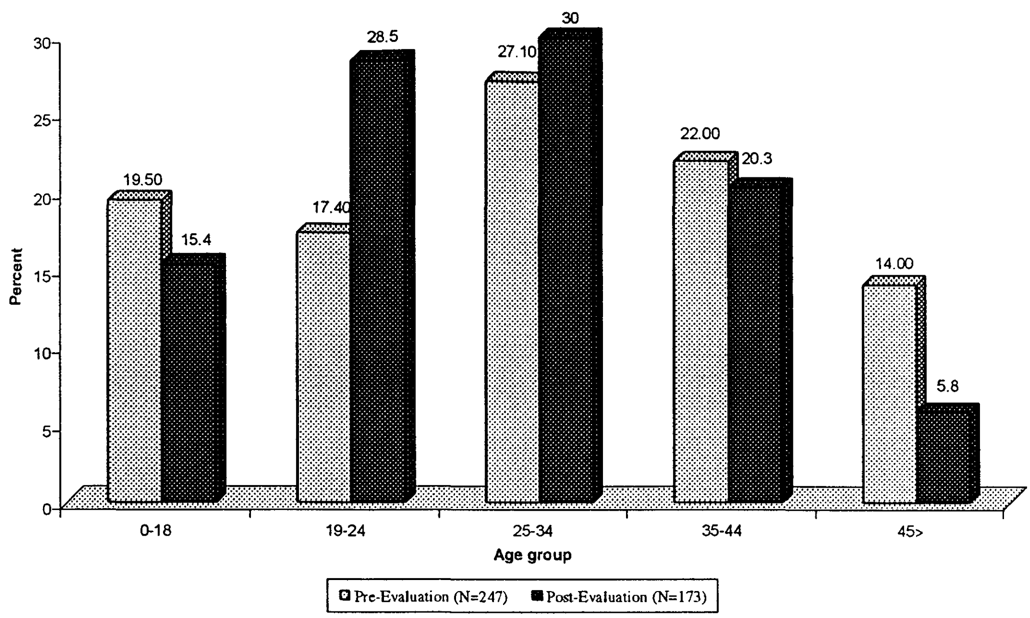
The sample number of RTA casualties enrolled for injury severity assessment during January to June 1998, the 'pre-evaluation' period, was 247. The descriptive analysis of the data showed that 85.7% of the sample population were males and 14.3% were females (Fig.15).

Fig. (15)
Gender Distribution of RTA Casualties
in the Pre and Post-Evaluations



The age distribution in the pre-evaluation period revealed that 44% were from the young middle age group (19 to 34 years). Those 18 years below contributed 20%, those of the age group (35-44 years) contributed 22% while those above 45 years represented 14% of RTA injuries only (Fig.16).

Fig. (16)
Age Distribution of RTA Casualties in the pre and post Evaluations



Asians had the highest contribution among the nationalities (43%), while UAE nationals had 28% and other Arabs had 29% (Fig.17). Most road user types involved in RTAs in the pre-evaluation period were motor vehicle and motorcycle drivers (44%), passengers (22%) and pedestrians (18%) (Fig.18).

Fig. No (17)
Distribution of RTA casualty according to Nationality in the pre/post-evaluation

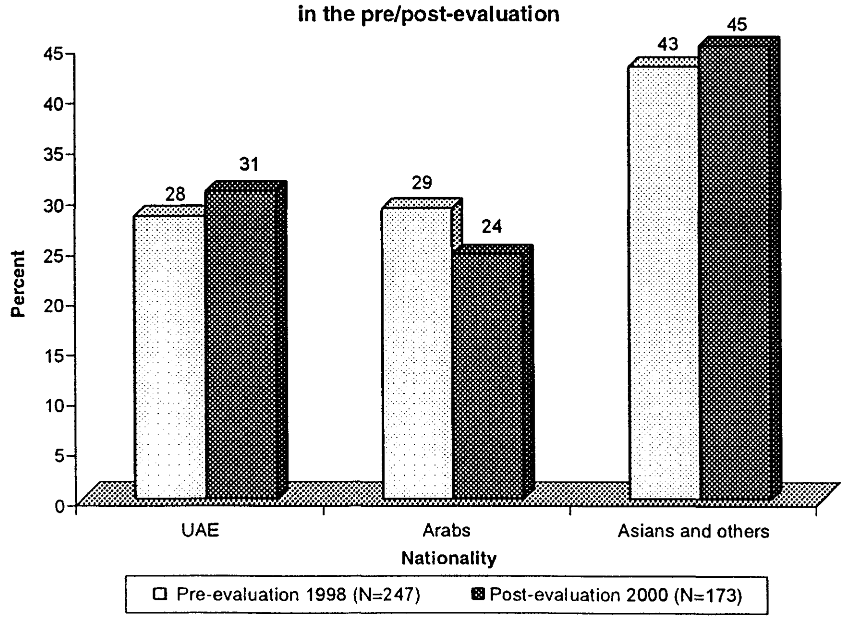
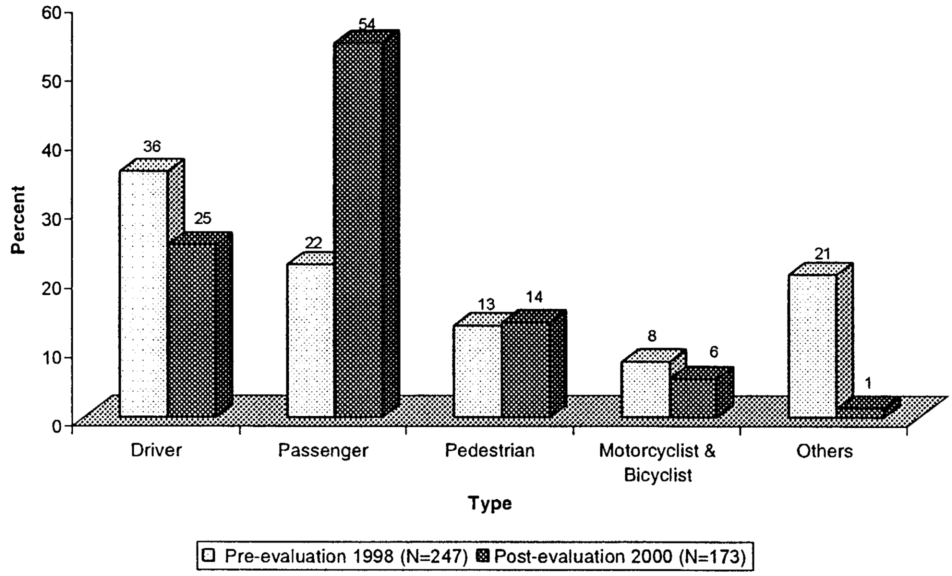


Fig. No (18)
Distribution of RTA casualties according to road user Type



The majority of RTA casualties were brought to hospital by other road users (67%), those brought by police were 16%, those who came by themselves were 11% while those brought by ambulance were 6% only (Fig.19).

Fig. (19)
Distribution of RTA Casualties according to Mode of Arrival to Hospital in pre/post-evaluation

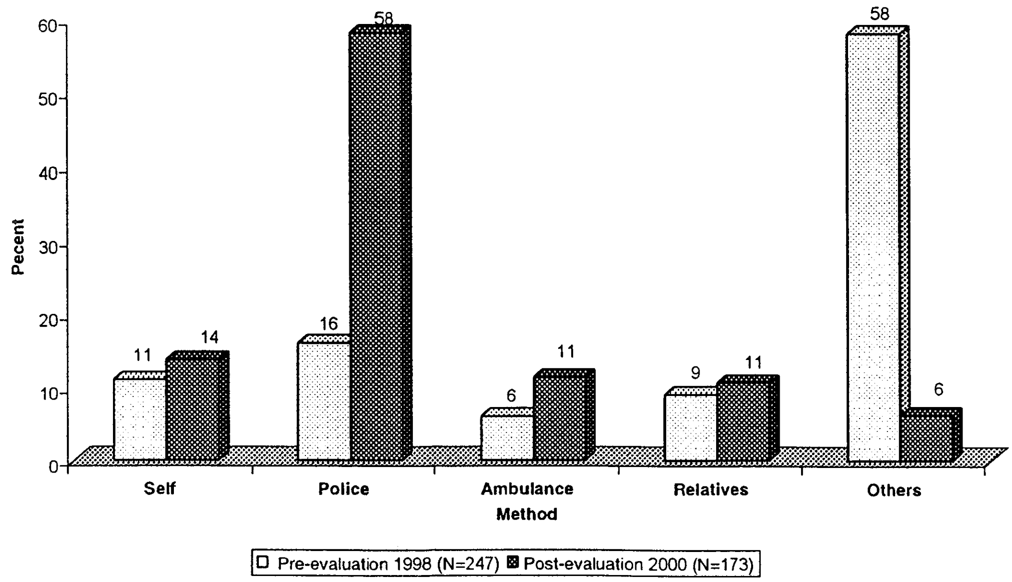
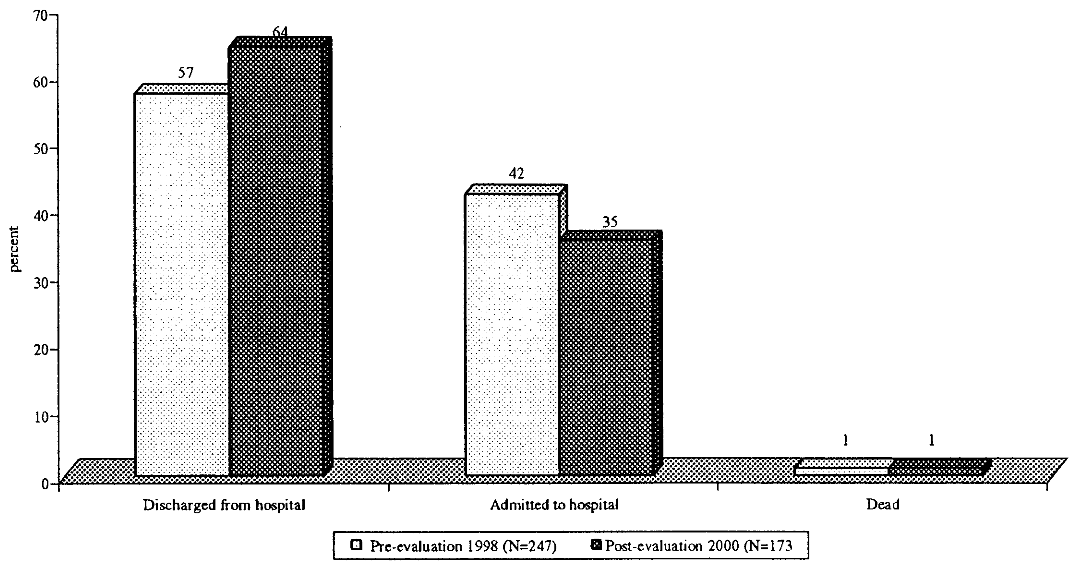
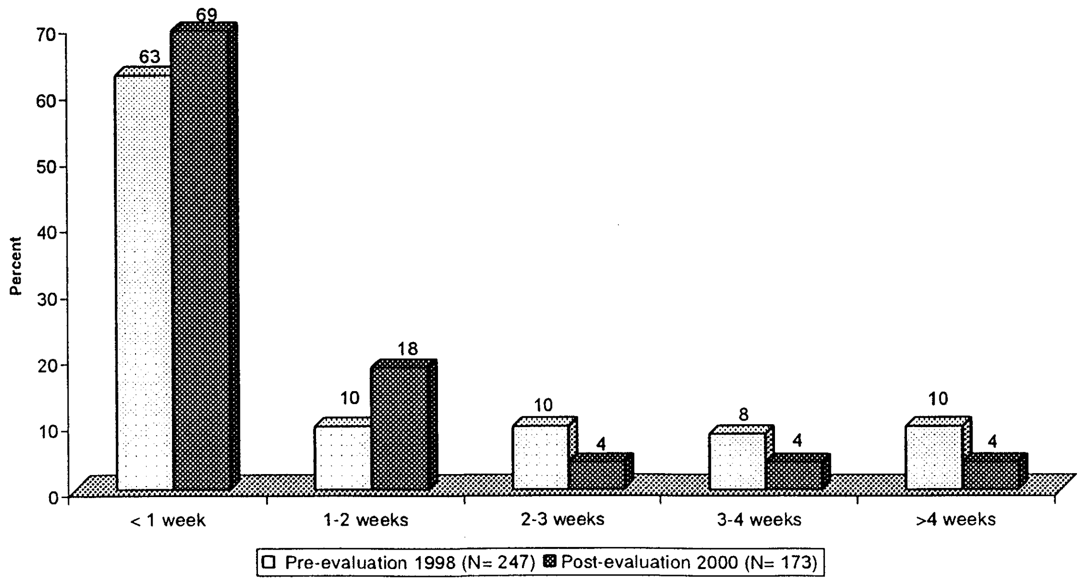


Fig. (20)
Distribution of RTA Outcomes Upon Arrival to Hospital
in the Pre and Post Evaluations



Out of the total number of casualties brought alive to the Emergency Room (ER) at the hospital 57% were discharged after basic treatment, 41% were admitted to hospital wards and 2% died (Fig.20). Out of those admitted to hospital wards 63% spent less than a week, 10% spent 1-2 weeks, 9% spent 2-3 weeks, 8% spent 3-4 weeks and 10% more than 4 weeks in the pre-evaluation. (Fig.21).

Fig. No (21)
Distribution of hospital bed days spent by RTA casualties
in the pre/post evaluations



Of the total number of casualties admitted to hospital-wards 90% were discharged after treatment without complications while 10% were transferred to specialised hospitals for further treatment of disability and other neurological complications (Fig.22).

Fig. (22)
Hospital Wards Outcomes of RTA Casualties in the Pre and Post Evaluations

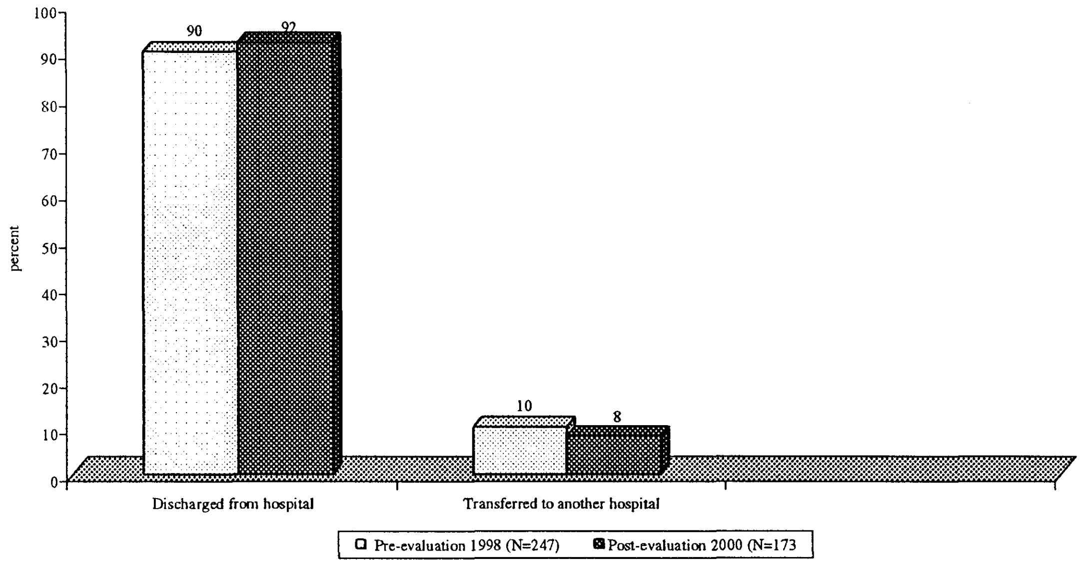
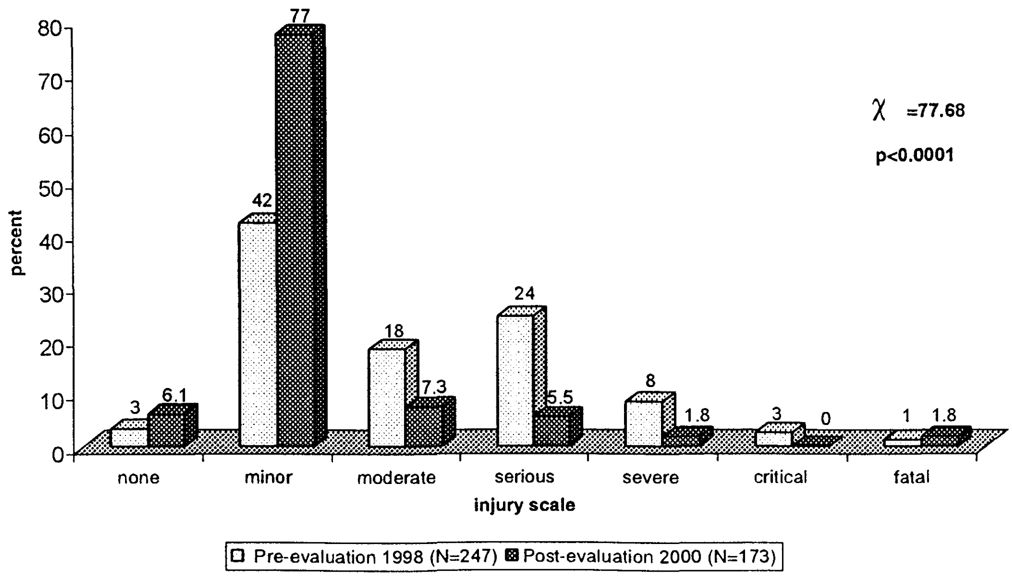


Fig. (23)
Distribution of RTA Injury Severity in the Pre and Post Evaluations



The analysis of injury severity, in the pre-evaluation period, using the abbreviated injury severity scores (AIS) revealed that of the total number of RTA victims received alive at the hospital 3% had no injury, 42% had minor injury, 18% had moderate injury, 24% had serious injury, 8% had severe injury, 3% had critical injury and 2% died (Fig.23).

8.3.2 RTA Injury Severity Assessment in the Post-evaluation Period

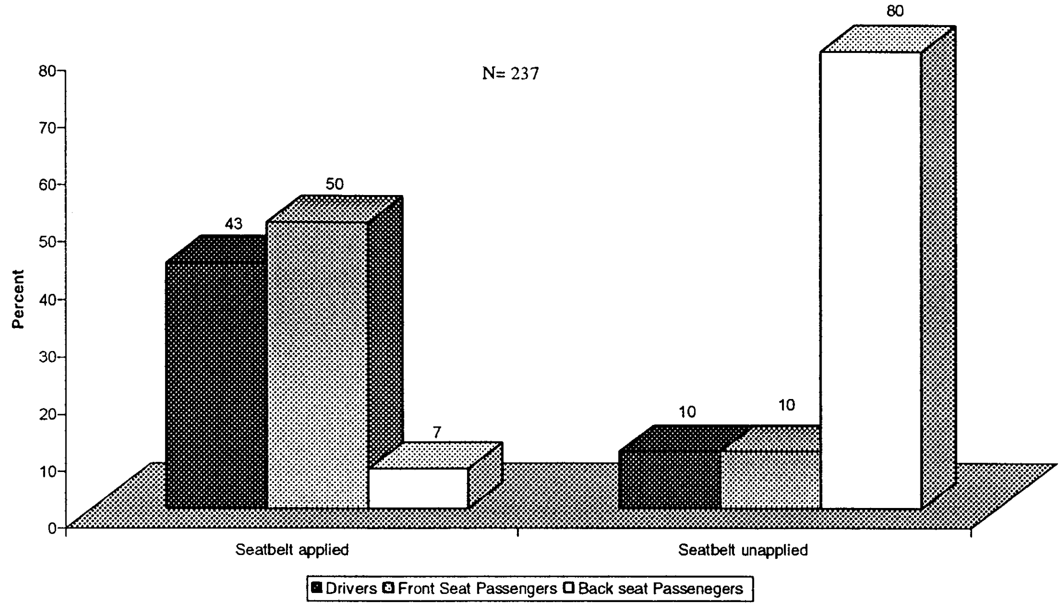
The sample number of RTA casualties enrolled for injury severity assessment after the enforcement of seatbelt legislation 'the post evaluation period', during February to August 2000, was 173 cases. The descriptive analysis of the data showed that 82% of the post-evaluation sample were males while 18% were females (Fig.15).

The age distribution, in the post evaluation sample, revealed that the young middle age group (19-34 years) was the group sustaining the highest RTA injuries in the UAE. Collectively they contributed to 54% of RTA injuries. Those of the age group (35-44 years) contributed 20%, those above 45 years contributed 8% while those 18 years below contributed 16% only (Fig.16). Asians were the highest among other nationalities in sustaining RTAs in the UAE (45%), followed by UAE (31%) and other Arabs (24%) (Fig.17). Most RTA victims were back seat passengers (29%), front seat passengers (26%) and drivers (24%), while pedestrians and cyclists represented 21% of RTA victims (Fig.18).

The analysis revealed that out of the total number of casualties 58% were brought to hospital by police, 17% by relatives, 14% by other road users, and 11% by ambulance (Fig.19). Of the total number of victims brought alive to the ER at the hospital 64% were discharged after receiving basic treatment, 35% were admitted to hospital wards and 2% died (Fig.20).

Out of the total number of motor vehicle occupants, 59% were found using seatbelts while 41% were not using them or any other restraint at the time of the RTA (Fig.24). Out of total number of occupants 86% of front seat passengers were found using seatbelts while 20% only of back seat passengers were using them (Fig. 24).

Fig. (24)
Pattern of Seatbelt Use among MV Users in the Post Evaluation Period



The study revealed that 73% of patients who sustained 'No Injury or Minor Injury' were discharged from the ER and 27% were kept under observation for a day or two, while all of those sustaining moderate or higher injury severity were admitted to hospital wards. It has also been revealed that of those admitted to hospital wards 69% spent less than a week, 18% one to two weeks, 4% two to three weeks, 4% spent three to four weeks and 4% spent more than four weeks (Fig.21). The analysis of final injury outcomes revealed that 89% of casualties were discharged without obvious complications, after completing treatment, and 11% were discharged with partial disability and complications (Fig. 22). The analysis of RTA injury severity, in the post-evaluation period, using the AIS, revealed that of the total number of RTA victims brought alive to hospital 6% were suffering no injury, 79% minor injuries, 8% moderate injuries, 6% serious injuries, 2% severe injuries and 2% died (Fig. 23).

CHAPTER 9

THE ECONOMIC IMPACT OF THE PROBLEM OF RTAS IN THE UAE DURING 1995

CHAPTER 9

THE ECONOMIC IMPACT OF RTAS IN THE UAE DURING 1995

9.1 RTA Fatality Costs in the UAE

RTA fatality costs during 1995 were derived by estimating the unit costs of the following components:

- Productivity losses in the workplace due to premature death;
- Losses in household production;
- Medical cots prior to death;
- Premature funeral costs;
- Emergency, police and insurance administration;
- Legal and court costs;
- Employer/workplace costs;
- Property damage costs.

9.1.1 Unit Cost of RTA Fatality Productivity Losses in the UAE

Using the HC approach, the models and data described in the methods chapter (7.2.1) the study calculated the overall productivity losses, which resulted from 690 RTA deaths in the UAE during 1995. The estimates were based on the number of years of healthy potential life lost (YPLL) per fatality and the discounted average annual workplace productivity losses over the years (Tables: 1-5). Tables (6-9) presents the results of these calculations per age, gender and nationality. Table (10) presents total productivity losses from RTA fatalities and the average Unit Cost per RTA fatality using the mean interest rate of 4.2% for discounting. Tables (10-12) presents results of sensitivity analysis for productivity losses using the mean interest rate ±2SD (i.e. 6.722% and 3.858%) to discount the average Unit Cost per RTA fatality productivity loss in the UAE.

Table (1)
Potential Years of Productivity Lost due to RTA Deaths among UAE Males during 1995

Age Group	Age mid point	Potential Years of Productivity Lost per age group	Deaths among UAE National Males	Total Years of Productivity lost for UAE males
0-1	1	48	3	144
1-4	3	48	3	144
5-9	7	48	9	432
10-14	12	48	13	624
15-19	17	48	18	864
20-24	22	43	47	2021
25-29	27	38	52	1976
30-34	32	33	14	462
35-39	37	28	11	308
40-44	42	23	6	138
45-49	47	18	2	36
50-54	52	13	3	39
55-59	57	8	1	8
60 +	62	5	22	110
Total			204	7306

Table (2)
Potential Years of Productivity Lost due to RTA Deaths among UAE Females during 1995

Age Group	Age mid point	Potential Years of Productivity Lost per age group	Deaths among UAE National Females	Total Years of Productivity lost for UAE females
0-1	1	48	2	96
1-4	3	48	3	144
5-9	7	48	2	96
10-14	12	48	2	96
15-19	17	48	2	96
20-24	22	43	5	215
25-29	27	38	6	228
30-34	32	33	6	198
35-39	37	28	2	56
40-44	42	23	3	69
45-49	47	18	2	36
50-54	52	13	2	26
55-59	57	8	3	24
60 +	62	5	2	10
Total			42	1390

Table (3)

Potential Years of Productivity Lost due to RTA Deaths Among Expatriate Males in the UAE during 1995

Age Group	Age mid point	Potential Years of Productivity Lost per age group	Deaths among Expatriate Males	Total Years of Productivity lost for Expatriate males
0-1	1	48	3	144
1-4	3	48	8	384
5-9	7	48	2	96
10-14	12	48	2	96
15-19	17	48	36	1728
20-24	22	43	58	2494
25-29	27	38	73	2774
30-34	32	33	66	2178
35-39	37	28	39	1092
40-44	42	23	31	713
45-49	47	18	23	414
50-54	52	13	20	260
55-59	57	8	11	88
60 +	62	5	19	95
Total			391	12556

Table (4)

Potential Years of Productivity Lost due to RTA Deaths Among Expatriate Females in the UAE during 1995

Age Group	Age mid point	YPLL	Deaths among expatriate females	Total YPLL of expatriates females
0-1	1	48	0	0
1-4	3	48	3	144
5-9	7	48	2	96
10-14	12	48	1	48
15-19	17	48	6	288
20-24	22	43	11	473
25-29	27	38	9	342
30-34	32	33	12	396
35-39	37	28	2	56
40-44	42	23	1	23
45-49	47	18	1	18
50-54	52	13	2	26
55-59	57	8	1	8
60 +	62	5	2	10
Total			53	1928

Table (5)
Total Years of Productivity Lost due to RTA Fatalities in the UAE According to Age, Sex and Citizenship during 1995
(in YPLL)

Age mid point	Total RTA Deaths	Productivity losses for UAE males	Productivity losses for UAE females	Productivity lost for Expatriate males	Productivity lost for Female Expatriates	Total Productivity losses due to RTAs
1	8	144	96	144	0	384
3	17	144	144	384	144	816
7	15	432	96	96	96	720
12	18	624	96	96	48	864
17	62	864	96	1728	288	2976
22	121	2021	215	2494	473	5203
27	140	1976	228	2774	342	5320
32	98	462	198	2178	396	3234
37	54	308	56	1092	56	1512
42	41	138	69	713	23	943
47	28	36	36	414	18	504
52	27	39	26	260	26	351
57	16	8	24	88	8	128
62+	45	110	10	95	10	225
Total	690	7306	1390	12556	1928	23180

Table (6)
Present Value (PV) of Workplace Productivity Loss from RTA Deaths among Expatriate Females in the UAE during 1995
(Value in AED)

Age Group	Age mid point	YPLL	Number of Deaths	Productivity lost per expatriate female	Total PV of productivity lost
0-1	1	48	0	1,562,486.04	-
1-4	3	48	3	1,562,486.04	4,687,458
5-9	7	48	2	1,562,486.04	3,124,972
10-14	12	48	1	1,562,486.04	1,562,486
15-19	17	48	6	1,562,486.04	9,374,916
20-24	22	43	11	1,504,975.85	16,554,734
25-29	27	38	9	1,434,330.54	12,908,975
30-34	32	33	12	1,347,550.08	16,170,601
35-39	37	28	2	1,240,949.27	2,481,899
40-44	42	23	1	1,110,001.19	1,110,001
45-49	47	18	1	949,145.02	949,145
50-54	52	13	2	751,549.86	1,503,100
55-59	57	8	1	508,824.63	508,825
60 +	62	5	2	337,331.32	674,663
Total			53		71,611,774

Table (7)

Present Value (PV) of Workplace Productivity Loss from RTA Deaths among Expatriate Males in the UAE during 1995

(Value in AED)

Age Group	Age mid point	YPLL	Number of Deaths	Productivity lost per expatriate male	Total PV of productivity lost
0-1	1	43	3	1,562,486.04	4,687,458.11
1-4	3	43	8	1,562,486.04	12,499,888.29
5-9	7	43	2	1,562,486.04	3,124,972.07
10-14	12	43	2	1,562,486.04	3,124,972.07
15-19	17	43	36	1,562,486.04	56,249,497.30
20-24	22	38	58	1,504,975.85	87,288,599.50
25-29	27	33	73	1,434,330.54	104,706,129.60
30-34	32	28	66	1,347,550.08	88,938,305.60
35-39	37	23	39	1,240,949.27	48,397,021.46
40-44	42	18	31	1,110,001.19	34,410,036.92
45-49	47	13	23	949,145.02	21,830,335.51
50-54	52	8	20	751,549.86	15,030,997.13
55-59	57	3	11	508,824.63	5,597,070.96
60 +	62	2	19	337,331.32	6,409,295.03
Total			391		492,294,579.56

Table (8)

Present Value (PV) of Workplace Productivity Loss from RTA Deaths among UAE Males during 1995

(Value in AED)

Age Group	Age mid point	YPLL	Number of Deaths of UAE males	Productivity lost for UAE male deaths	Total productivity lost
0-1	1	43	3	1,562,486.04	4,687,458.11
1-4	3	43	3	1,562,486.04	4,687,458.11
5-9	7	43	9	1,562,486.04	14,062,374.33
10-14	12	43	13	1,562,486.04	20,312,318.47
15-19	17	43	18	1,562,486.04	28,124,748.65
20-24	22	38	47	1,504,975.85	70,733,865.11
25-29	27	33	52	1,434,330.54	74,585,188.21
30-34	32	28	14	1,347,550.08	18,865,701.19
35-39	37	23	11	1,240,949.27	13,650,441.95
40-44	42	18	6	1,110,001.19	6,660,007.15
45-49	47	13	2	949,145.02	1,898,290.04
50-54	52	8	3	751,549.86	2,254,649.57
55-59	57	3	1	508,824.63	508,824.63
60 +	62	2	22	337,331.32	7,421,288.98
Total			204		268,452,614.49

Table (9)

Present Value (PV) of Workplace Productivity Loss from RTA Deaths among UAE females, according to age group, during 1995

(Value in AED)

Age Group	Age mid point	YPLL	RTA Deaths of UAE Females	PV of Productivity lost per UAE female	Total productivity lost for UAE females
0-1	1	43	2	1,562,486.04	3,124,972.07
1-4	3	43	3	1,562,486.04	4,687,458.11
5-9	7	43	2	1,562,486.04	3,124,972.07
10-14	12	43	2	1,562,486.04	3,124,972.07
15-19	17	43	2	1,562,486.04	3,124,972.07
20-24	22	38	5	1,504,975.85	7,524,879.27
25-29	27	33	6	1,434,330.54	8,605,983.25
30-34	32	28	6	1,347,550.08	8,085,300.51
35-39	37	23	2	1,240,949.27	2,481,898.54
40-44	42	18	3	1,110,001.19	3,330,003.57
45-49	47	13	2	949,145.02	1,898,290.04
50-54	52	8	2	751,549.86	1,503,099.71
55-59	57	3	3	508,824.63	1,526,473.90
60 +	62	2	2	337,331.32	674,662.63
Total			42		52,817,937.83

Table (10)

Total Present Value (PV) of Workplace Productivity Losses from RTA Fatalities in the UAE during 1995 (using the mean interest rate of 4.2%)

(Value in AED)

Age Group	Total RTA Deaths	PV of productivity lost for UAE males	PV of Productivity lost for UAE females	PV of Productivity lost for Expatriate males	PV of Productivity lost for expatriate females	Total PV of Productivity lost due to RTAs in the UAE
0-1	8	4,687,458.11	3,124,972.07	4,687,458.11	-	12,499,888.29
1-4	17	4,687,458.11	4,687,458.11	12,499,888.29	4,687,458.11	26,562,262.61
5-9	15	14,062,374.33	3,124,972.07	3,124,972.07	3,124,972.07	23,437,290.54
10-14	18	20,312,318.47	3,124,972.07	3,124,972.07	1,562,486.04	28,124,748.65
15-19	62	28,124,748.65	3,124,972.07	56,249,497.30	9,374,916.22	96,874,134.24
20-24	121	70,733,865.11	7,524,879.27	87,288,599.50	16,554,734.39	182,102,078.27
25-29	140	74,585,188.21	8,605,983.25	104,706,129.60	12,908,974.88	200,806,275.95
30-34	98	18,865,701.19	8,085,300.51	88,938,305.60	16,170,601.02	132,059,908.31
35-39	54	13,650,441.95	2,481,898.54	48,397,021.46	2,481,898.54	67,011,260.49
40-44	41	6,660,007.15	3,330,003.57	34,410,036.92	1,110,001.19	45,510,048.83
45-49	28	1,898,290.04	1,898,290.04	21,830,335.51	949,145.02	26,576,060.62
50-54	27	2,254,649.57	1,503,099.71	15,030,997.13	1,503,099.71	20,291,846.12
55-59	16	508,824.63	1,526,473.90	5,597,070.96	508,824.63	8,141,194.12
60 +	45	7,421,288.98	674,662.63	6,409,295.03	674,662.63	15,179,909.27
Total	690	268,452,614.49	52,817,937.83	492,294,579.56	71,611,774.45	885,176,906.33

Table (10-A)
Weighted Overall Average Unit Cost of RTA Fatality Productivity Loss in the UAE during 1995

	Weighted averages
UAE males' Unit Cost Average * 28% (AED 1315944.19 * 0. 30)	394783.25
UAE females' Unit Cost Average * 06% (AED 1257569.93* 0.06)	75454.20
Expatriate males' Unit Cost Average *59% (AED 1259065.42 * 0.57)	717667.29
Expatriate females Unit Cost Average *07% (AED 1351165.55* 0.07)	94581.59
Weighted Overall Average Unit Cost of Productivity lost	**1,282,486.33**

As shown on table (10) total productivity losses that resulted from 690 RTA fatalities in the UAE during 1995 amounted to AED 885 millions (using an effective mean discounting rate of 4.2% and an average annual productivity loss of AED 76200 per individual, growing at an effective growth rate of 1.2%). Based on these estimates, the weighted average unit cost of productivity loss per RTA fatality in the UAE amounted to AED 1,282,000 (Tables:10 and 10-A).

Table (11) shows total productivity losses from RTA fatalities in the UAE during 1995 using an upper bound effective discounting rate of 6.772%, an annual productivity of AED 76,200 per individual and an effective productivity growth rate of 1.2%. The calculations revealed that total productivity losses amounted to AED 647 millions only and the Unit Cost per individual RTA fatality was AED 947,000 (Tables: 11 and 11-A).

Table (12) shows the total productivity losses from RTA fatalities in the UAE during 1995 using a lower bound effective discounting rate of 3.858%, an annual productivity of AED 76,200 per individual and an effective productivity growth rate of 1.2%. The analysis showed that total productivity losses, which resulted from 690 RTA fatalities in the UAE during 1995, amounted to AED 928 millions and the Unit Cost per individual RTA fatality was AED 1,344,000 (Tables:12 and 12-A).

Table (11)

Total Present Value (PV) of Workplace Productivity Losses of RTA Fatalities in UAE during 1995 (using a discounting rate of 6.772%)

Value (in AED)

Age Group	Total RTA Deaths	PV of productivity lost for UAE males	PV of Productivity lost for UAE females	PV of Productivity lost for Expatriate males	PV of Productivity lost for expatriate females	Total PV of Productivity lost due to RTAs in the UAE
0-1	8	3,230,317.81	2,153,545.21	3,230,317.81	-	8,614,180.83
1-4	17	3,230,317.81	3,230,317.81	8,614,180.83	3,230,317.81	18,305,134.27
5-9	15	9,690,953.44	2,153,545.21	2,153,545.21	2,153,545.21	16,151,589.06
10-14	18	13,998,043.85	2,153,545.21	2,153,545.21	1,076,772.60	19,381,906.87
15-19	62	19,381,906.87	2,153,545.21	38,763,813.74	6,460,635.62	66,759,901.45
20-24	121	49,725,544.74	5,289,951.57	61,363,438.19	11,637,893.45	128,016,827.95
25-29	140	53,660,185.87	6,191,559.91	75,330,645.55	9,287,339.86	144,469,731.19
30-34	98	13,940,623.64	5,974,552.99	65,720,082.89	11,949,105.98	97,584,365.50
35-39	54	10,401,267.29	1,891,139.51	36,877,220.39	1,891,139.51	51,060,766.70
40-44	41	5,255,542.59	2,627,771.30	27,153,636.72	875,923.77	35,912,874.38
45-49	28	1,558,555.93	1,558,555.93	17,923,393.15	779,277.96	21,819,782.97
50-54	27	1,935,495.81	1,290,330.54	12,903,305.40	1,290,330.54	17,419,462.28
55-59	16	459,060.81	1,377,182.44	5,049,668.95	459,060.81	7,344,973.01
60 +	45	6,915,737.12	628,703.37	5,972,682.05	628,703.37	14,145,825.92
Total	690	193,383,553.58	38,674,246.19	363,209,476.09	51,720,046.50	646,987,322.37

Table (11-A)

Weighted Overall Average Unit Cost of RTA Fatality Productivity Loss in the UAE during 1995

	Weighted average
UAE males' Unit Cost Average * 30% (AED 947958.59* 0. 30)	284387.58
UAE females' Unit Cost Average * 06% (AED 920815.38* 0.06)	64455.00
Expatriate males' Unit Cost Average *57% (AED 928924.49* 0.57)	529486.96
Expatriate females Unit Cost Average *07% (AED 975849.92 * 0.07)	68309.49
Weighted Overall Average Unit Cost of Productivity lost	**946,639.03**

Table (12)

Total Present Value of Workplace Productivity Lost from RTA Fatalities in the UAE during 1995 (using a discounting rate of 3.858%)

Value (in UAE Dirhams)

Age Group	Total RTA Deaths	Total PV of productivity lost for UAE males	Total PV of Productivity lost for UAE females	Total PV of Productivity lost for Expatriate males	Total PV of Productivity lost for expatriate females	Total PV of Productivity lost due to RTAs in the UAE
0-1	8	4,962,416.73	3,308,277.82	4,962,416.73	-	13,233,111.28
1-4	17	4,962,416.73	4,962,416.73	13,233,111.28	4,962,416.73	28,120,361.46
5-9	15	14,887,250.19	3,308,277.82	3,308,277.82	3,308,277.82	24,812,083.64
10-14	18	21,503,805.82	3,308,277.82	3,308,277.82	1,654,138.91	29,774,500.37
15-19	62	29,774,500.37	3,308,277.82	59,549,000.74	9,924,833.46	102,556,612.39
20-24	121	74,601,075.32	7,936,284.61	92,060,901.46	17,459,826.14	192,058,087.52
25-29	140	78,334,815.71	9,038,632.58	109,970,029.75	13,557,948.87	210,901,426.91
30-34	98	19,722,927.87	8,452,683.37	92,979,517.08	16,905,366.74	138,060,495.06
35-39	54	14,198,507.00	2,581,546.73	50,340,161.18	2,581,546.73	69,701,761.64
40-44	41	6,889,062.35	3,444,531.17	35,593,488.80	1,148,177.06	47,075,259.37
45-49	28	1,951,736.05	1,951,736.05	22,444,964.53	975,868.02	27,324,304.64
50-54	27	2,302,965.09	1,535,310.06	15,353,100.62	1,535,310.06	20,726,685.83
55-59	16	516,056.79	1,548,170.37	5,676,624.68	516,056.79	8,256,908.63
60 +	45	7,492,899.76	681,172.71	6,471,140.70	681,172.71	15,326,385.87
Total	690	282,100,435.76	55,365,595.65	515,251,013.18	75,210,940.03	927,927,984.62

Table (12-A)

Weighted Overall Average Unit Cost of RTA Fatality Productivity Loss in the UAE during 1995

	Weighted averages
UAE males' Unit Cost Average * 30% (AED 1382845.27* 0. 30)	414853.59
UAE females' Unit Cost Average * 06% (AED 1318228.45* 0.06)	79093.71
Expatriate males' Unit Cost Average *57% (AED 1317777.52* 0.57)	751133.20
Expatriate females Unit Cost Average *07% (AED 1419074* 0.07)	99335.21
Weighted Overall Average Unit Cost of Productivity lost	**1,344,415.71**

9.1.2 **Household Productivity Losses from RTA Fatalities in the UAE**

As described in the Methods chapter (section 7.2.1.4.) the calculation of household productivity losses was based on the market replacement method, i.e. the hourly cost of labour required replacing household functions. Hence, the official hourly minimum wage equivalent to AED 17.4 was used for the calculation. Household productivity was assumed to last for two hours per day and to continue throughout the year and throughout the individual's expected life span. The future losses of this element were discounted using the effective discounting rate (4.2%). The results are presented in tables (13-17) below.

Table (13)

Present Value (PV) of Household Productivity Losses from RTA Expatriate Female Deaths in the UAE, according to age group during 1995

Value (in AED)

Age Group	Age mid point	YPLL	Number of Deaths	Years of household Productivity lost	PV of Productivity lost per individual per age group	Productivity losses of expatriate females
0-1	1	55	0	0	270,958.46	0
1-4	3	55	3	165	270,958.46	812875.38
5-9	7	55	2	110	270,958.46	541916.92
10-14	12	55	1	55	270,958.46	270958.46
15-19	17	55	6	330	270,958.46	1625750.76
20-24	22	50	11	550	263,770.80	2901478.8
25-29	27	45	9	405	254,941.49	2294473.41
30-34	32	40	12	480	244,095.61	2929147.32
35-39	37	35	2	70	230,772.56	461545.12
40-44	42	30	1	30	214,406.57	214406.57
45-49	47	25	1	25	194,302.64	194302.64
50-54	52	20	2	40	169,607.05	339214.1
55-59	57	15	1	15	139,271.07	139271.07
60 +	62	10	2	20	102,006.46	204012.92
Total			53	2295		12,929,353.47

Table (14)

Present Value of Household Productivity Losses from RTA Deaths Among Expatriate Males in the UAE, during 1995

(Value in AED)

Age Group	Age mid point	YPLL	Number of RTA Deaths	Years of household Productivity lost	Productivity lost per individual per age group	Total productivity lost
0-1	1	55	3	165	270,958.46	812875.38
1-4	3	55	8	440	270,958.46	2167667.68
5-9	7	55	2	110	270,958.46	541916.92
10-14	12	55	2	110	270,958.46	541916.92
15-19	17	55	36	1980	270,958.46	9754504.56
20-24	22	50	58	2900	263,770.80	15298706.4
25-29	27	45	73	3285	254,941.49	18610728.77
30-34	32	40	66	2640	244,095.61	16110310.26
35-39	37	35	39	1365	230,772.56	9000129.84
40-44	42	30	31	930	214,406.57	6646603.67
45-49	47	25	23	575	194,302.64	4468960.72
50-54	52	20	20	400	169,607.05	3392141
55-59	57	15	11	165	139,271.07	1531981.77
60 +	62	10	19	190	102,006.46	1938122.74
Total			391	15255		90,816,566.63

Table (15)

Present Value (PV) of Household Productivity Losses from RTA Deaths Among UAE Males during 1995

(Value in AED)

Age Group	Age mid point	YPLL	No. of RTA Deaths	Total Years of household Productivity lost	PV of Productivity losses per individual male per age group	Hhousehold productivity losses due to RTA deaths for UAE Males
0-1	1	55	3	165	270,958.46	812875.38
1-4	3	55	3	165	270,958.46	812875.38
5-9	7	55	9	495	270,958.46	2438626.14
10-14	12	55	13	715	270,958.46	3522459.98
15-19	17	55	18	990	270,958.46	4877252.28
20-24	22	50	47	2350	263,770.80	12397227.6
25-29	27	45	52	2340	254,941.49	13256957.48
30-34	32	40	14	560	244,095.61	3417338.54
35-39	37	35	11	385	230,772.56	2538498.16
40-44	42	30	6	180	214,406.57	1286439.42
45-49	47	25	2	50	194,302.64	388605.28
50-54	52	20	3	60	169,607.05	508821.15
55-59	57	15	1	15	139,271.07	139271.07
60 +	62	10	22	220	102,006.46	2244142.12
Total			204	8690		48,641,389.98

Table (16)

Household Productivity Losses from RTA Deaths among UAE Females During 1995

(Value in AED)

Age Group	Age mid point	YPLL	No. of RTA Deaths	Total Years of household Productivity lost	Productivity lost per individual per age group	Household productivity lost due to RTA deaths
0-1	1	55	2	110	270,958.46	541916.92
1-4	3	55	3	165	270,958.46	812875.38
5-9	7	55	2	110	270,958.46	541916.92
10-14	12	55	2	110	270,958.46	541916.92
15-19	17	55	2	110	270,958.46	541916.92
20-24	22	50	5	250	263,770.80	1318854
25-29	27	45	6	270	254,941.49	1529648.94
30-34	32	40	6	240	244,095.61	1464573.66
35-39	37	35	2	70	230,772.56	461545.12
40-44	42	30	3	90	214,406.57	643219.71
45-49	47	25	2	50	194,302.64	388605.28
50-54	52	20	2	40	169,607.05	339214.1
55-59	57	15	3	45	139,271.07	417813.21
60 +	62	10	2	20	102,006.46	204012.92
Total			42	1680		9,748,030.00

As shown in table (17) the total cost of lifetime RTA household productivity losses in the UAE, which resulted from 690 RTA deaths during 1995 were AED 162 millions. Based on these estimates, the weighted average unit cost of household productivity losses per RTA fatality in the UAE amounted to AED 235,000 (Table 17-A). Table (18) shows the results of sensitivity analysis applying an upper-bound effective discount rate of 6.772%. The analysis revealed that the total household productivity losses from RTA fatalities amounted to AED 104 millions and the unit cost estimate amounted to AED 151,000 (Table 18-A). Table (19) shows household productivity losses, applying a lower bound effective discount rate of 3.858%. The results revealed a total household productivity loss of AED 171 millions and a unit cost amounting to AED 247,000 per individual (Table 19-A).

Table (17)

Household Productivity Losses from RTA Fatalities in the UAE during 1995
(using an affective mean discounting rate of 4.2%)
(Value in AED)

Age Group	RTA Deaths	Total Household productivity losses for UAE males	Total Household Productivity losses for UAE females	Total Household Productivity losses for Male Expatriates	Total Household Productivity losses for female Expats.	Total Household Productivity losses due to RTAs in the UAE
0-1	8	812875.38	541916.92	812875.38	0	2167667.68
1-4	17	812875.38	812875.38	2167667.68	812875.38	4606293.82
5-9	15	2438626.14	541916.92	541916.92	541916.92	4064376.9
10-14	18	3522459.98	541916.92	541916.92	270958.46	4877252.28
15-19	62	4877252.28	541916.92	9754504.56	1625750.76	16799424.52
20-24	121	12397227.6	1318854	15298706.4	2901478.8	31916266.8
25-29	140	13256957.48	1529648.94	18610728.77	2294473.41	35691808.6
30-34	98	3417338.54	1464573.66	16110310.26	2929147.32	23921369.78
35-39	54	2538498.16	461545.12	9000129.84	461545.12	12461718.24
40-44	41	1286439.42	643219.71	6646603.67	214406.57	8790669.37
45-49	28	388605.28	388605.28	4468960.72	194302.64	5440473.92
50-54	27	508821.15	339214.1	3392141	339214.1	4579390.35
55-59	16	139271.07	417813.21	1531981.77	139271.07	2228337.12
60 +	45	2244142.12	204012.92	1938122.74	204012.92	4590290.7
Total	**690**	**48,641,389.98**	**9,748,030.00**	**90,816,566.63**	**12,929,353.47**	**162,135,340.1**

Table (17-A)

Weighted Overall Average Unit Cost of RTA Household Fatality Productivity Lost in the UAE during 1995

	Weighted average
UAE males' weighted Average * 30% (AED 238438 * 0. 30)	71531.45
UAE females' weighted Average * 06% (AED 232096 * 0.06)	13925.76
Expatriate males' weighted Average *57% (AED 232267* 0.59)	132392.43
Expatriate females weighted Average *07% (AED 243950* 0.07)	17076.50
Overall Weighted Average Unit Cost of Household Productivity lost	**234,926.14**

Table (18)

Sensitivity Analysis of Household Productivity Losses from RTA Fatalities in the UAE during 1995 (using an effective discounting rate of 6.772%)

(Value in AED)

Age Group	RTA Deaths	Total Household productivity losses for Expat. Females	Total Household Productivity losses for UAE Males	Total Household Productivity losses for UAE Females	Total Household Productivity losses for Expat. Males	HH Productivity losses due to RTAs in the UAE
0-1	8	0	488,762.85	325,841.90	488,762.85	1,303,367.60
1-4	17	488,762.85	488,762.85	488,762.85	1,303,367.60	2,769,656.16
5-9	15	325,841.90	1,466,288.55	325,841.90	325,841.90	2,443,814.26
10-14	18	162,920.95	2,117,972.36	325,841.90	325,841.90	2,932,577.11
15-19	62	977,525.70	2,932,577.11	325,841.90	5,865,154.22	10,101,098.93
20-24	121	1,778,092.96	7,597,306.29	808,224.07	9,375,399.25	19,559,022.57
25-29	140	1,438,190.20	8,309,543.35	958,793.46	11,665,320.48	22,371,847.49
30-34	98	1,885,546.19	2,199,803.88	942,773.09	10,370,504.02	15,398,627.18
35-39	54	306,533.32	1,685,933.26	306,533.32	5,977,399.73	8,276,399.62
40-44	41	147,680.08	886,080.50	443,040.25	4,578,082.58	6,054,883.41
45-49	28	139,599.22	279,198.43	279,198.43	3,210,781.97	3,908,778.05
50-54	27	255,820.82	383,731.23	255,820.82	2,558,208.18	3,453,581.04
55-59	16	111,002.79	111,002.79	333,008.38	1,221,030.71	1,776,044.67
60 +	45	173,092.55	1,904,018.03	173,092.55	1,644,379.21	3,894,582.34
Total	690	8,190,609.53	30,850,981.49	6,292,614.83	58,910,074.60	104,244,280.44

Table (18-A)

Weighted Overall Average Unit Cost of RTA Household Fatality Productivity Lost in the UAE during 1995

	Weighted average
UAE males' weighted Average * 30% (AED 151230.30 * 0. 30)	45369.08
UAE females' weighted Average * 06% (AED 149824* 0.06)	8989.45
Expatriate males' weighted Average *57% (AED 150665.08 * 0.57)	85879.09
Expatriate females weighted Average *07% (AED 154539.79 * 0.07)	10817.78
Overall Weighted Average Unit Cost of Household Productivity lost	**151,055.4**

Table (19)
Sensitivity Analysis for Household Productivity Losses from RTA Fatalities in the UAE during 1995 (using an effective discounting rate of 3.858%)
(Value in AED)

Age Group	RTA Deaths	Total Household productivity losses of Expat. Females	Total Household Productivity losses of UAE Males	Total Household Productivity losses for UAE Females	Total Household Productivity losses for Expat. Males	Total Household Productivity losses due to RTAs in the UAE
0-1	8	0	864,564.07	576,376.05	864,564.07	2,305,504.19
1-4	17	864,564.07	864,564.07	864,564.07	2,305,504.19	4,899,196.40
5-9	15	576,376.05	2,593,692.21	576,376.05	576,376.05	4,322,820.35
10-14	18	288,188.02	3,746,444.30	576,376.05	576,376.05	5,187,384.42
15-19	62	1,729,128.14	5,187,384.42	576,376.05	10,374,768.84	17,867,657.45
20-24	121	3,075,979.16	13,142,820.04	1,398,172.34	16,218,799.20	33,835,770.75
25-29	140	2,423,687.53	14,003,527.94	1,615,791.69	19,658,798.84	37,701,805.99
30-34	98	3,081,708.98	3,595,327.15	1,540,854.49	16,949,399.41	25,167,290.03
35-39	54	483,434.22	2,658,888.22	483,434.22	9,426,967.34	13,052,724.01
40-44	41	223,480.43	1,340,882.60	670,441.30	6,927,893.44	9,162,697.77
45-49	28	201,443.79	402,887.57	402,887.57	4,633,207.10	5,640,426.04
50-54	27	349,630.75	524,446.12	349,630.75	3,496,307.49	4,720,015.11
55-59	16	142,638.41	142,638.41	427,915.23	1,569,022.53	2,282,214.58
60 +	45	207,513.50	2,282,648.48	207,513.50	1,971,378.23	4,669,053.70
Total	690	13,647,773.05	51,350,715.61	10,266,709.36	95,549,362.77	170,814,560.79

Table (19-A)
Weighted Overall Average Unit Cost of RTA Household Fatality Productivity Lost in the UAE during 1995

	Weighted average
UAE males' weighted Average * 30% (AED 251719 * 0. 30)	75516
UAE females' weighted Average * 06% (AED 244445* 0.06)	14667
Expatriate males' weighted Average *57% (AED 244371 * 0.57)	139292
Expatriate females weighted Average *07% (AED 257505* 0.07)	18025
Overall Weighted Average Unit Cost of Household Productivity lost	**247,500**

9.1.3 **Medical Costs prior to RTA Deaths**

Based on the RTA injury sample collected from Al-Ain hospital the study analysed the distribution of medical outcomes following fatally RTA crashes in the UAE. The analysis revealed that in the UAE 51% of RTA deaths take place on the roadside and during transportation, 19% at Accidents and Emergency Room (ER), 24% in the Intensive Care Unit (ICU) and 6% after admission to orthopaedic or surgical wards. The analysis also revealed that 87.5% of the victims admitted to the ICU received advanced medical intervention while 12.5% received special intervention. Of those admitted to the ER 69.5% received basic assessment and 30.5% received advanced treatment before referral to ICU or medical wards. Of those admitted to medical wards 91.3% received conservative intervention while 8.7% received operative procedure. Those admitted to the ICU spent a mean duration of 6.57 hospital bed days (SD = ± 5.86) and those admitted to hospital wards spent a duration of 8.63 hospital bed days (SD = ± 8.76).

Those parameters were applied to the RTA fatality data of 1995 to estimate the distribution of medical procedures before and after death in the UAE. Thus, out of 690 RTA fatalities: 352 were estimated to have occurred on the roadside or during transportation to hospital, 131 at the ER, 166 at the ICU and 41 in surgical or orthopaedic wards. Of those estimated to reach hospitals alive (338), 235 were estimated to have received basic assessment and intervention at the ER and 103 received special intervention. Of those transferred from the ER to the ICU (166), 152 received advanced intervention and 14 received special intervention. Of those admitted to medical wards (41) 37 received advanced treatment and 4 received special intervention. Table (20) shows immediate outcomes following fatally RTA crashes and medical procedures to victims before death.

Table (20)
Distribution of RTA Fatalities according to Place of Death and Medical Intervention before Death in the UAE during 1995

Place of Death	**Medical Procedures before and after Death**					
	Basic	*Advanced*	*Special*	*Conservative*	*Autopsy*	*Mortuary*
On the Road	0	0	0	0	352	352
HB* days	0	0	0	0	0	0
ER	235	103	0	0	0	131
HB days	(235)	(103)	0	0	0	0
ICU	0	152	14	0	0	166
HB days	0	(999)	(121)	0	0	0
Medical Ward	0	0	4	37	0	41
HB days	0	0	(35)	(352)	0	0
Total	235	255	18	37	352	690
HB days	(235)	(1102)	(156)	(352)	(352)	(2197)

* Hospital bed days.

Based on these data, medical costs prior to death were calculated, using the rates and charges described in section (7.2.1.5.) of the methods chapter. The results are presented in table (21) below:

Table (21)
Medical Costs prior to Death in the UAE during 1995
(Value in AED)

Cost Item	**Frequency**	**Rate**	**Total cost**
Hospital bed days	2197	200	439400
Medical Procedure at ER	338	500	169000
Medical procedure at Intensive Care Unit	Advanced = 152 Special = 14	6000 6000	912000 84000
Medical Procedure at Hospital ward or operation theatre	Advanced = 37 Special = 4	6000 6000	222000 24000
X ray and laboratory costs	338	2500	845000
Autopsy	352	4000	1408000
Mortuary	690 cases X 2 days	200	276000
Hospital Administration	690	1000	690000
Overhead expenses	690	1500	1035000
Miscellaneous expenses	690	800	768000
Total Costs			**5,268,000**
Average Unit Cost per individual	**5,268,000 / 690**		**7643.78**

The analysis revealed that total medical costs prior to RTA deaths that took place in the UAE during 1995 amounted to AED 5.2 millions and the average unit cost per deceased individual amounted to AED 7,643.78.

9.1.4 **Premature Funeral Costs**

As explained in the methods chapter (section 7.2.1.6) the average funeral costs per fatality were estimated by taking the difference in the value of funeral costs in the present versus the end of the expected life span of the fatally injured person, using the effective general interest rate for discounting (4.2%). Table (22) presents the results of the estimation.

Table (22)
Difference in the Value of Funeral Costs (present versus end of expected life span) for RTA fatalities in the UAE during 1995
(Value in AED)

Age Group	Premature funeral Costs of UAE males	Premature funeral Costs of UAE females	Premature funeral Costs of Expatriate males	Premature funeral Costs of Expatriate females	Total Premature Funeral Costs
0-1	14,195.55	9,463.70	86,256.27	-	109,915.52
1-4	13,108.94	13,108.94	212,409.94	79,653.73	318,281.55
5-9	33,442.99	7,431.78	45,157.63	45,157.63	131,190.03
10-14	39,202.56	6,031.16	36,647.10	18,323.55	100,204.37
15-19	43,666.96	4,851.88	501,184.80	73,703.65	623,407.29
20-24	63,672.89	9,647.41	492,411.80	46,896.36	612,628.46
25-29	37,786.87	6,045.90	560,233.85	64,289.13	668,355.75
30-34	12,754.77	2,319.05	387,508.52	42,273.66	444,856
35-39	7,768.73	863.19	167,840.19	10,490.01	186,962.12
40-44	3,068.44	613.69	89,494.71	3,728.95	96,905.79
45-49	807.22	807.22	56,406.68	2,452.46	60,473.58
50-54	680.20	453.47	27,554.02	2,755.40	31,443.09
55-59	77.81	233.42	5,200.57	472.78	5,984.58
60 +	1,121.43	101.95	5,884.96	619.47	7,727.81
Total	271,355.35	61,972.76	2,674,191.04	390,816.78	3,398,335.93

The results show that total premature funeral costs in the UAE amounted to AED 3.4 millions and the Unit Cost per RTA fatality amounted to AED 6,032.

9.1.5 Emergency Services Cost (Police, Fire and Ambulance)

As explained in the methods chapter (section 7.2.1.7.) the costs of police administration, fire and ambulance services were estimated, based on data obtained from the Civil Defence in Al-Ain city, the Traffic Police department and the Ambulances Services department of Dubai police. Table (23) shows the Unit Cost estimate of police administration following RTA deaths in the UAE.

Table (23)
Police Unit Cost per RTA Fatality in the UAE during 1995
(Value in AED)

Cost Items	Total cost
Average Overhead Costs per response	
1. Patrol car	250
2. Crane or towing vehicle X 0.50	300
3. Special equipment	100
Total	**650**
Manning Costs per response:	
1. Average cost of 2 police officers	177
2. Investigation and documentation	354
3. Communication	100
4. Administration and prosecution	799
Total	**1430**
Grand Total	**2080**
Grand Total adjusted to 1995 rates using CPI = 4.1%	**1740**
Average Cost per police response in the UAE during 1995	**1740**

The results show that the average Unit Cost of police administration per RTA fatality during 1995 amounted to AED 1,740.

Table (24) shows the unit cost estimate per Fire call.

Table (24)
Fire Services Cost per RTA Fatality in the UAE during 1995
Value in (UAE Dirhams)

Cost Item	**Total cost**
Overhead costs	
1. Ambulance vehicles	2762000
2. Equipment	632418
3. Buildings	2600000
Total	5,994,418
Operating Costs	
1. Manpower	8421100
2. Vehicle Maintenance	476200
3. Consumables	500000
4. Water and electricity	600000
5. Communications	90000
6. Fuel and lubricants	450000
Total	10,537,300
Administration Cost	
1. Management manpower	1200000
2. Training, Seminars and Conferences	140000
3. Office materials	320000
4. Miscellaneous Expenditure	40000
Total	1,700,000
Grand Total	18,231,718
Grand Total adjusted to 1995 rates using CPI = 4.1%	15,256,825
Total calls during 1995	1400
Average Cost per call	10,897.7
Unit Cost per RTA fatality (Av. cost X0.175)	1907.1

Table (25) shows the Unit Cost estimate of ambulance services per call in the UAE. Based on the official reports of the Dubai Ambulance Services department the study estimated the average unit cost per RTA fatality.

Table (25)
Ambulance Services Cost per RTA Fatality in the UAE during 1995
Value in (UAE Dirhams)

Cost Item	Total cost
Overhead costs	
1. Ambulance vehicles	2648000
2. Equipment	485714
3. Buildings	2000000
Total	**5,133,714**
Operating Costs	
1. Manpower	8738100
2. Vehicle Maintenance	305846
3. Consumables	100000
4. Water and electricity	300000
5. Communications	240000
6. Fuel and lubricants	211886
Total	**9,895,832**
Administration Cost	
1. Management manpower	688800
2. Training, Seminars and Conferences	134670
3. Office materials	250000
4. Miscellaneous Expenditure	26934
Total	**1,100,404**
Grand Total	**16,129,950**
Grand Total adjusted to 1995 rates using CPI = 4.1%	**13,699,918**
Total calls during 1995	**17084**
Average Cost per call	**801.92**

The overall unit cost of emergency services per RTA fatality (police administration, fire and ambulance) was estimated by adding together the unit cost estimates of those three components:

- Unit cost of police administration per RTA fatality AED 1740.00
- Unit cost per fire response per RTA fatality AED 1907.10
- Unit cost of Ambulance call per RTA fatality AED 801.92
- Unit Cost per emergency services per RTA fatality **AED 4449.02**

9.1.6 **Insurance Administration Costs**

Using the time series data described in the Methods chapter (section 7.2.1.8.) the analysis revealed that the average insurance cost per RTA, for motor vehicles that had comprehensive insurance policies, increased annually by 3.4% between 1988-1991, compared to 48% for third party insurance policies (Tables: 26 and 27). Based on those proportions insurance administration costs were expected to have reached AED 2092.5 per accident in 1995 for comprehensive insurance policies and AED 1205.2 per accident for third party insurance policies. The weighted average cost of insurance administration (calculated by using the percentage share of each policy type (45% and 55%) during the period 1988-1991) was AED 1604 per RTA fatality.

Table (26)
Insurance Administration Cost per Accident in the UAE for Comprehensive Insurance Policies (1988-1991) in Thousands AED

Year	Premiums paid	Claims paid-out	Total RTAs	Insurance Administration Costs	Ins. Admin. Costs per Accident	% Difference of Admin. Cost
1988	181864	119219	36852	62645	1699	--
1989	205085	145734	39284	59351	1510	- 11.1%
1990	217317	150433	42429	66884	1576	4.4%
1991	257718	177196	43700	80522	1842	16.8%
Av.						3.4%

Table (27)
Insurance Administration Cost per Accident in the UAE For Third Party Insurance Policies (1988-1991) in Thousands AED

Year	Premiums paid (Th. DH)	Claims paid-out (Th. DH)	Total number of accidents	Insurance Administration Costs (Th. DH)	Ins. Costs per Accident (DH)	% Difference of Admin. Cost
1988	40763	38162	10522	2601	247.2	--
1989	55291	50036	13639	5255	382.3	55%
1990	61335	48224	16183	13111	810.2	112%
1991	67669	57177	16715	10492	627.7	-22.6%
						(Avr.) 48%

9.1.7 **Legal and Court Costs per RTA Fatality**

The study used the methods described in the methods chapter (section 7.2.1.9) to compute legal and court costs per RTA fatality. To achieve that the study used the official court compensation for wrongful death in the UAE, known as (Diyatte) which amount AED 150,000, as basis for the calculations, in addition to estimating the other variables of the model, from various sources, as follows:

$TLC_{RTAs} = E_{cas.} [RTA_{comp} (CF+CME) + RTA_{3p} (AF+CF+CME)] + AP_{cas.} [RTA_{comp} (CF+CME) + RTA_{3p} (CF+CME)].$

$E_{cas.}$	= 1
AP_{cas}	= 0.25
RTA_{comp}	= 0.45
AF	= 0.125 X AED 150,000 = AED 18750
CF	= AED 1000
CME	= AED 750
RTA_{3p}	= 0.55.

Based on the above model the average Unit Cost of legal expenses per RTA fatality in the UAE was calculated to amount AED 20,500 during 1995.

9.1.8 **Employer workplace Costs per RTA Fatality in the UAE**

Based on the methods explained in the methods chapter (section 7.2.1.0.) the study estimated the average Unit Cost of employer workplace losses per RTA fatality to be as follows:

- Production downtime losses per deceased labourer	= AED 38,100.00
- Direct costs of replacement (administrative expenses adjusted to 1995 rates using CPI = 4.1%)	= AED 2,342.87
- Average Unit Cost per RTA fatality	= **AED 40,442.87**

9.2 Costs of Nonfatal RTA Injuries

According to the methods described in section (7.2.2.1) the components of RTA injury costs were close to those of RTA fatalities described above but the methods for their calculation differed. The main sources for outcomes of nonfatal RTA injuries in the UAE were from the MoH and MoI annual reports. Unfortunately, these reports neither report final RTA injury outcomes nor classify RTA injuries by severity; compared to the practice elsewhere. Instead, a crude classification to fatal, nonfatal and no injury exist. Therefore, to estimate RTA injury outcomes and costs in the UAE the study opted to estimate parameters for RTA injury outcomes, using a sample of RTA injury obtained from Al-Ain hospital of the UAE. Those parameters were applied to the nonfatal RTA injury data of 1995 to estimate the extent of disability and medical procedures required maintaining casualties to their pre-trauma status. The resulting data was used to measure and assess productivity losses, in addition to hospital and rehabilitation costs of RTA injuries in the UAE during 1995.

In general the cost components of RTA injuries included the cost elements identified for RTA fatalities, with the exception of premature funeral costs. As with RTA fatalities, only RTA injury-related costs were considered in this section. Property damage and lost quality of life were considered separately, and then added to the total cost per injury scale.

Thus, the cost elements of RTA injuries comprised the following items:

1. Productivity losses at workplace due to temporary and permanent disability.
2. Household productivity losses due to disability.
3. Outpatient and inpatient medical costs.
4. Emergency services costs.
5. Insurance administration costs
6. Legal and court costs.
7. Employer/workplace Costs.
8. Property damage costs.

9.2.1 **Unit Costs of Productivity Losses due to RTA Injuries**

Based on the HC approach, the models and data described in the methods chapter (7.2.2.2), the study calculated productivity losses from RTA injuries in the UAE during 1995. These calculations were based on injury outcomes of RTAs in the UAE during 1995, estimated on the basis of AIS categories (Table 28). Estimates of disability adjusted life years (DALYs) were achieved through estimating parameters for years of livings with disability (YLDs) to measure disability-outcomes from RTA injuries. YLD measurement adjustments are based on RTA injury severity, duration of inpatient and outpatient medical treatment, rehabilitation and age of the injured individual. These estimates were obtained by analysing the sample of injury data of Al-Ain hospital. The resulting parameters were applied to the nonfatal RTA injury data of 1995, to estimate disability-outcomes of RTA injuries per AIS categories in the UAE during that year (Table 29).

The total DALYs, which resulted from 9691 injuries in the UAE during 1995, were 33,821 (Table 29). The discounted annual workplace productivity losses per RTA injury per AIS category during 1995 was calculated, using a discounting rate of 4.2%, and an average annual productivity of AED 76,200. Results are presented in (Tables: 30-34). Table (35) presents total productivity losses from RTA injury per AIS categories. Table (35-A) shows the average unit cost of productivity loss per RTA injury per AIS category, using the mean interest rate of 4.2%.

Table (28)
Distribution of RTA Injuries in the UAE according to (AIS) Categories During 1995

Age Group	Minor Injuries	Moderate Injuries	Serious Injuries	Severe Injuries	Critical Injuries	Total Injuries
0-1	0	0	0	42	0	42
1-4	170	42	121	40	0	377
5-9	129	68	122	41	0	372
10-14	45	80	140	20	0	285
15-19	263	260	305	61	30	943
20-24	1177	283	244	82	29	1815
25-29	740	123	404	82	59	1408
30-34	829	80	367	142	119	1537
35-39	482	366	204	130	51	1233
40-44	218	122	204	80	21	645
45-49	89	41	81	0	30	241
50-54	129	204	41	0	0	374
55-59	45	40	122	0	0	207
60 +	129	42	41	0	0	212
Total	4445	1751	2396	720	339	9691

Table (28) shows the distribution of nonfatal RTA injuries, on the basis of the AIS during 1995. As explained in the methods section (6.3.3) the UAE police and health sources do not classify nonfatal RTA injuries by severity or any other outcome measure. To facilitate understanding the severity of those injuries in the UAE the study analysed a sample of RTA patients (N=247) admitted to Al-Ain hospital (section 8.3.1). The analysis provided parameters for RTA injury severity in the UAE on the basis of AIS categories. Those parameters were applied to the nonfatal RTA injury data of 1995 to estimate the pattern of the distribution of RTA injuries in the UAE. The results are presented on Table (28) above.

Table (29)

Disability Adjusted Life Years (DALYs) from RTA Injuries in the UAE during 1995

Age Group	Age mid point	DALYs due to Minor Injuries	DALYs due to Moderate Injuries	DALYs due to Serious Injuries	DALYs due to Severe Injuries	DALYs due to Critical Injuries	Total
0-1	1	0	0	0	1806	0	1806
1-4	3	8.70	6.30	36.30	1720	0	1771.3
5-9	7	6.45	12.00	36.60	1763	0	1818.05
10-14	12	2.25	12.00	42.00	860	0	916.25
15-19	17	13.15	42.60	91.50	2623	1290	4060.25
20-24	22	58.85	42.45	73.20	3116	1102	4392.5
25-29	27	37.00	18.45	121.20	2706	1947	4829.65
30-34	32	41.45	12.00	110.10	3976	3332	7471.55
35-39	37	24.10	54.90	61.20	2990	1173	4303.2
40-44	42	10.90	18.30	61.20	1440	378	1908.4
45-49	47	4.45	6.15	24.30	0	390	424.9
50-54	52	6.45	30.60	12.30	0	0	49.35
55-59	57	2.25	6.00	36.60	0	0	44.85
60 +	62	6.45	6.30	12.30	0	0	25.05
Total		222.45	268.05	718.80	23000	9612	33821.3

Table (30)

Present Value (PV) of Workplace Productivity Loss from Minor RTA Injuries in the UAE, according to age group, during 1995

(Value in AED)

Age Group	Age mid point	YLDs due to minor injuries	Number of non-fatal minor injuries	Total YLDs per age group	Total productivity lost due to nonfatal minor injuries
0-1	1	0.05	0	0	0.00
1-4	3	0.05	174	42	618,393.76
5-9	7	0.05	129	68	458,464.34
10-14	12	0.05	45	80	159,929.42
15-19	17	0.05	263	260	934,698.61
20-24	22	0.05	1177	283	4,183,042.83
25-29	27	0.05	740	123	2,629,950.46
30-34	32	0.05	829	80	2,946,255.32
35-39	37	0.05	482	366	1,713,021.79
40-44	42	0.05	218	122	774,769.19
45-49	47	0.05	89	41	316,304.85
50-54	52	0.05	129	204	458,464.34
55-59	57	0.05	45	40	159,929.42
60 +	62	0.05	125	42	458,464.34
Total			4445	1751	15,811,688.67

Table (31)
Present Value (PV) of Workplace Productivity Loss from Moderate RTA Injuries in the UAE, according to age group, during 1995
(Value in AED)

Age Group	Age mid point	YLDs	Number of moderate injuries	Total YLDs per age group	Total productivity lost due to nonfatal moderate injuries
0-1	1	0.15	0	0	0.00
1-4	3	0.15	42	6.3	446,904.21
5-9	7	0.15	68	12	851,246.11
10-14	12	0.15	80	12	851,246.11
15-19	17	0.15	260	42.6	3,021,923.68
20-24	22	0.15	283	42.45	3,011,283.10
25-29	27	0.15	123	18.45	1,308,790.89
30-34	32	0.15	80	12	851,246.11
35-39	37	0.15	366	54.9	3,894,450.94
40-44	42	0.15	122	18.3	1,298,150.31
45-49	47	0.15	41	6.15	436,263.63
50-54	52	0.15	204	30.6	2,170,677.57
55-59	57	0.15	40	6	425,623.05
60 +	62	0.15	42	6.3	446,904.21
Total			1751	268.05	19,014,709.90

Table (32)
Present Value (PV) of Workplace Productivity Loss from Serious RTA Injuries in the UAE, according to age group, during 1995
(Value in AED)

Age Group	Age mid point	YLDs	Number of non-fatal serious injuries	Total YLDs per age group	Total productivity lost due nonfatal serious injuries
0-1	1	0.3	0	0	0.00
1-4	3	0.3	121	36.3	2,567,282.64
5-9	7	0.3	122	36.6	2,588,499.86
10-14	12	0.3	140	42	2,970,409.67
15-19	17	0.3	299	91.5	6,471,249.64
20-24	22	0.3	244	73.2	5,176,999.71
25-29	27	0.3	404	121.2	8,571,753.62
30-34	32	0.3	367	110.1	7,786,716.78
35-39	37	0.3	204	61.2	4,328,311.23
40-44	42	0.3	204	61.2	4,328,311.23
45-49	47	0.3	81	24.3	1,718,594.17
50-54	52	0.3	41	12.3	869,905.69
55-59	57	0.3	122	36.6	2,588,499.86
60 +	62	0.3	41	12.3	869,905.69
Total			2,390	718.8	50,836,439.79

Table (33)
Present Value (PV) of Workplace Productivity Loss from Severe RTA Injuries in the UAE, according to age group, during 1995
(Value in AED)

Age Group	Age mid point	YLDs	Number of severe RTA injuries	Total YLDs per age group	Productivity lost due to severe RTA injuries	Total productivity lost due nonfatal severe RTA injuries
0-1	1	43	42	1806	1,528,326.95	64,189,731.77
1-4	3	43	40	1720	1,528,326.95	61,133,077.88
5-9	7	43	41	1763	1,528,326.95	62,661,404.82
10-14	12	43	20	860	1,528,326.95	30,566,538.94
15-19	17	43	61	2623	1,528,326.95	93,227,943.76
20-24	22	38	82	3116	1,454,850.86	119,297,770.48
25-29	27	33	82	2706	1,365,025.35	111,932,079.03
30-34	32	28	142	3976	1,255,212.47	178,240,170.04
35-39	37	23	130	2990	1,120,964.73	145,725,415.00
40-44	42	18	80	1440	956,845.07	76,547,605.55
45-49	47	13	0	0	756,206.58	0
50-54	52	8	0	0	510,923.32	0
55-59	57	3	0	0	211,061.23	0
60 +	62	2	0	0	143,514.74	0
Total			720	23000		943,521,737.28

Table (34)
Present Value (PV) of Workplace Productivity Loss from Critical RTA Injuries in the UAE, according to age group, during 1995
(Value in AED)

Age Group	Age mid point	YLDs	Number of critical RTA injuries	Total YLDs per age group	Productivity lost due to critical RTA injuries	Total productivity lost due to critical RTA injuries
0-1	1	43	0	0	1,528,326.95	0.00
1-4	3	43	0	0	1,528,326.95	0.00
5-9	7	43	0	0	1,528,326.95	0.00
10-14	12	43	0	0	1,528,326.95	0.00
15-19	17	43	30	1290	1,528,326.95	45,849,808.41
20-24	22	38	29	1102	1,454,850.86	42,190,674.93
25-29	27	33	59	1947	1,365,025.35	80,536,495.89
30-34	32	28	119	3332	1,255,212.47	149,370,283.34
35-39	37	23	51	1173	1,120,964.73	57,169,201.27
40-44	42	18	21	378	956,845.07	20,093,746.46
45-49	47	13	30	390	756,206.58	22,686,197.25
50-54	52	8	0	0	510,923.32	0.00
55-59	57	3	0	0	211,061.23	0.00
60 +	62	2	0	0	143,514.74	0.00
Total			339	9612		417,896,407.55

Table (35)
Workplace Productivity Losses from RTA Injuries in the UAE During 1995
(Value in AED)

Age Group	Productivity Losses from Minor RTA Injuries	Productivity Losses from Moderate RTA Injuries	Productivity Losses from Serious RTA Injuries	Productivity Losses from Severe RTA Injuries	Productivity Losses from Critical RTA Injuries	Total Productivity Losses from RTA Injuries
0-1	0.00	0.00	0.00	64,189,731.77	0.00	64,189,731.77
1-4	618,393.76	446,904.21	2,567,282.64	61,133,077.88	0.00	64,765,658.48
5-9	458,464.34	851,246.11	2,588,499.86	62,661,404.82	0.00	66,559,615.12
10-14	159,929.42	851,246.11	2,970,409.67	30,566,538.94	0.00	34,548,124.14
15-19	934,698.61	3,021,923.68	6,471,249.64	93,227,943.76	45,849,808.41	149,505,624.10
20-24	4,183,042.83	3,011,283.10	5,176,999.71	119,297,770.48	42,190,674.93	173,859,771.05
25-29	2,629,950.46	1,308,790.89	8,571,753.62	111,932,079.03	80,536,495.89	204,979,069.89
30-34	2,946,255.32	851,246.11	7,786,716.78	178,240,170.04	149,370,283.34	339,194,671.58
35-39	1,713,021.79	3,894,450.94	4,328,311.23	145,725,415.00	57,169,201.27	212,830,400.23
40-44	774,769.19	1,298,150.31	4,328,311.23	76,547,605.55	20,093,746.46	103,042,582.74
45-49	316,304.85	436,263.63	1,718,594.17	0.00	22,686,197.25	25,157,359.90
50-54	458,464.34	2,170,677.57	869,905.69	0.00	0.00	3,499,047.60
55-59	159,929.42	425,623.05	2,588,499.86	0.00	0.00	3,174,052.33
60 +	458,464.34	446,904.21	869,905.69	0.00	0.00	1,775,274.23
Total	15,811,688.67	19,014,709.90	50,836,439.79	943,521,737.28	417,896,407.55	1,447,080,983.17

Table (35-A)
Weighted Average Productivity loss from RTA Injuries per AIS categories in the UAE during 1995

AIS Category	Average Productivity Loss per AIS
Minor Injury (AIS 1)	3,557.19
Moderate Injury (AIS 2)	10,859.43
Serious Injury (AIS 3)	21,270.43
Severe Injury (AIS 4)	1,311,045.235153
Critical Injury (AIS 5)	1,232,732.764012

Tables (36 and 37) presents results of sensitivity analysis of productivity losses from RTA injuries using a plausible range of the mean interest rate ±2SD (i.e. 6.722% and 3.858%) to discount the average Unit Cost of productivity loss per RTA injury per AIS category in the UAE during 1995.

As shown on table (35) total productivity losses which resulted from 9691 RTA injuries in the UAE during 1995 amounted to AED 1.4 billion (using an effective mean discounting rate of 4.2% and an average annual productivity of AED 76200 per individual, growing at an effective growth rate of 1.2%). Based on these estimates, the weighted average unit cost of productivity loss per RTA injury per AIS category in the UAE amounted to AED 3,557 for minor injuries (AIS 1), AED 10,860 for moderate injuries (AIS 2), AED 21,270 for serious injuries, AED 1,311,000 for severe injuries (AIS 4) and AED 1,232,000 (Table 35-A).

Table (36)
Workplace Productivity Losses from RTA Injuries in the UAE during 1995 (using an effective discounting rate of 6.772%)
(Value in AED)

Age Group	Productivity Losses from Minor RTA Injuries	Productivity Losses from Moderate RTA Injuries	Productivity Losses from Serious RTA Injuries	Productivity Losses from Severe RTA Injuries	Productivity Losses from Critical RTA Injuries	Total Productivity Losses from RTA Injuries
0-1	0.00	0.00	0.00	44,435,593.17	0.00	44,435,593.17
1-4	610,152.30	440,390.80	2,525,080.63	42,319,612.54	0.00	45,895,236.27
5-9	452,354.29	838,839.61	2,545,949.06	43,377,602.86	0.00	47,214,745.82
10-14	157,798.01	838,839.61	2,921,580.89	21,159,806.27	0.00	25,078,024.78
15-19	922,241.69	2,977,880.62	6,364,872.66	64,537,409.13	31,739,709.41	106,542,113.51
20-24	4,127,294.57	2,967,395.12	5,091,898.13	84,617,985.41	29,925,872.89	126,730,446.12
25-29	2,594,900.58	1,289,715.90	8,430,847.72	81,652,224.20	58,749,771.07	152,717,459.47
30-34	2,906,989.97	838,839.61	7,658,715.63	134,270,905.02	112,522,800.69	258,198,250.93
35-39	1,690,192.00	3,837,691.22	4,257,160.73	113,870,089.48	44,672,112.03	168,327,245.46
40-44	764,443.68	1,279,230.41	4,257,160.73	62,342,237.04	16,364,837.22	85,007,909.09
45-49	312,089.39	429,905.30	1,690,343.23	0.00	19,354,958.09	21,787,296.02
50-54	452,354.29	2,139,041.01	855,605.83	0.00	0.00	3,447,001.13
55-59	157,798.01	419,419.81	2,545,949.06	0.00	0.00	3,123,166.88
60 +	452,354.29	440,390.80	855,605.83	0.00	0.00	1,748,350.92
Total	15,600,963.09	18,737,579.81	50,000,770.15	692,583,465.14	313,330,061.40	1,090,252,839.58

Table (36-A)
Weighted Average Productivity losses from RTA Injuries per AIS categories in UAE during 1995
(Value in AED)

AIS Category	Average Productivity Loss per AIS
Minor Injury (AIS 1)	3,509.78
Moderate Injury (AIS 2)	10,701.00
Serious Injury (AIS 3)	18,587.65
Severe Injury (AIS 4)	961,921.47
Critical Injury (AIS 5)	924,277.46

Table (37)
Workplace Productivity Losses from RTA Injuries in the UAE
During 1995 (Value in AED)
(Using an effective discounting rate of 3.858%)

Age Group	Productivity Losses from Minor RTA Injuries	Productivity Losses from Moderate RTA Injuries	Productivity Losses from Serious RTA Injuries	Productivity Losses from Severe RTA Injuries	Productivity Losses from Critical RTA Injuries	Total Productivity Losses from RTA Injuries
0-1	0.00	0.00	0.00	66,664,790.71	0.00	66,664,790.71
1-4	619,154.50	447,505.99	2,571,187.09	63,490,276.87	0.00	67,128,124.44
5-9	459,028.33	852,392.36	2,592,436.57	65,077,533.79	0.00	68,981,391.05
10-14	160,126.16	852,392.36	2,974,927.21	31,745,138.43	0.00	35,732,584.16
15-19	935,848.46	3,025,992.86	6,481,091.42	96,822,672.22	47,617,707.65	154,883,312.62
20-24	4,188,188.75	3,015,337.96	5,184,873.14	123,527,978.62	43,686,724.15	179,603,102.62
25-29	2,633,185.79	1,310,553.25	8,584,789.95	115,520,006.07	83,118,053.15	211,166,588.21
30-34	2,949,879.76	852,392.36	7,798,559.19	183,289,817.64	153,602,030.28	348,492,679.23
35-39	1,715,129.12	3,899,695.03	4,334,893.94	149,263,017.53	58,557,029.95	217,769,765.57
40-44	775,722.30	1,299,898.34	4,334,893.94	78,069,441.84	20,493,228.48	104,973,184.90
45-49	316,693.97	436,851.08	1,721,207.89	0.00	23,029,650.92	25,504,403.86
50-54	459,028.33	2,173,600.51	871,228.68	0.00	0.00	3,503,857.52
55-59	160,126.16	426,196.18	2,592,436.57	0.00	0.00	3,178,758.91
60 +	459,028.33	447,505.99	871,228.68	0.00	0.00	1,777,763.00
Total	15,831,139.99	19,040,314.24	50,913,754.27	973,470,673.72	430,104,424.58	1,489,360,306.80

Table (37-A)
Weighted Average Productivity loss per RTA Injury per AIS Category in the UAE during 1995
(Value in AED)

AIS Injury Scale	Average Productivity Loss per AIS
Minor Injury (AIS 1)	3,561
Moderate Injury (AIS 2)	10,873
Serious Injury (AIS 3)	21,302
Severe Injury (AIS 4)	1,352,042
Critical Injury (AIS 5)	1,268,744

Table (36) shows total productivity losses from RTA injuries in the UAE during 1995 using an upper bound effective discounting rate of 6.772%, an annual productivity of AED 76,200 per individual and an effective productivity growth rate of 1.2%. The calculations revealed that total productivity losses from RTA injuries amounted AED 1.1 billion and the unit costs per individual were AED 3,509 for minor injuries (AIS 1), AED 10,700 for moderate injuries (AIS 2), AED 18,587 for serious injuries (AIS 3), AED 962,000 for severe injuries (AIS 4) and AED 924,000 for critical injuries (Tables: 36 and 36-A). Tables (37 and 37-A) show results using a lower bound interest rate (3.858%). The total cost amounted to AED 1.5 billion and the unit costs per AIS category were AED 3,560 for minor injuries, AED 11,000 for moderate injuries, AED 21,300 for serious injuries, AED 1.3 million for severe injuries and AED 1.2 million per critical injury.

9.2.2 **Unit Cost of Household Productivity Losses from RTA Injuries**

The study used the AIS parameters derived for RTA injuries and the time loss estimates of RTA injuries (DALYs) derived from the analysis of the sample of Al-Ain hospital, as a basis to estimate household productivity losses from RTA injuries during 1995 (Tables 28 and 29). As illustrated in the Methods chapter (section 7.2.2.3) the computation of household productivity losses was based on the market replacement method and was achieved by using the mean effective discounting rate of 4.2%, 2 household working hours per day, an average hourly labour productivity replacement cost of AED 17.4 per individual and the assumption that household productivity continues throughout the year. The results are presented in table (38) below.

The results show that household productivity loss from RTA injuries amounted to AED 284 millions during 1995. Out of this, the contribution of minor injuries was AED 2.7 millions, moderate injuries was AED 3.4 millions, serious injuries was AED 8.1 millions, severe injuries was 189.6 millions and critical injuries was AED 79.3 millions. The average unit cost estimate of forgone household productivity was AED 621.48 for minor injuries, AED 1,860.62 for moderate injuries, AED 3,709.08 for serious injuries, AED 212,693.37 for severe injuries and AED 200,650.61 for critical injuries (Table 38-A).

Sensitivity analysis was performed using an upper and a lower bound rates equivalent to the mean interest rate ± 2SD (i.e. 6.722% and 3.858%) to estimate the average Unit Cost of forgone household productivity per RTA injury per AIS category in the UAE during 1995. Results of sensitivity analysis are shown on tables (39 and 40).

Table (38)

Household Productivity Losses from RTA Injuries in the UAE during 1995 (using the mean interest rate of 4.2% for discounting)

(Value in AED)

Age Group	Productivity Losses from Minor RTA Injuries	Household Productivity Losses from Moderate RTA Injuries	Household Productivity Losses from Serious RTA Injuries	Household Productivity Losses from Severe RTA Injuries	Household Productivity Losses from Critical RTA Injuries	Total Household Productivity Losses from RTA Injuries
0-1	-	-	-	10,536,490.00	-	10,536,490.00
1-4	108,138.48	78,146.36	448,886.81	10,034,752.38	-	10,669,924.03
5-9	80,171.63	148,850.22	452,596.62	10,285,621.19	-	10,967,239.66
10-14	27,966.85	148,850.22	519,373.17	5,017,376.19	-	5,713,566.43
15-19	163,450.69	528,418.28	1,131,491.54	15,302,997.39	7,526,064.29	24,652,422.19
20-24	731,488.45	526,557.65	905,193.23	19,605,604.42	6,933,689.37	28,702,533.12
25-29	459,899.28	228,857.21	1,498,762.57	18,419,418.06	13,252,995.92	33,859,933.04
30-34	515,211.49	148,850.22	1,361,499.66	29,373,757.74	24,616,036.42	56,015,355.53
35-39	299,556.02	680,989.75	756,800.90	24,053,813.21	9,436,495.95	35,227,655.83
40-44	135,483.84	226,996.58	756,800.90	12,657,259.92	3,322,530.73	17,099,071.97
45-49	55,312.21	76,285.74	300,494.48	-	3,758,341.05	4,190,433.48
50-54	80,171.63	379,568.06	152,102.14	-	-	611,841.83
55-59	27,966.85	74,425.11	452,596.62	-	-	554,988.58
60 +	80,171.63	78,146.36	152,102.14	-	-	310,420.13
Total	2,764,989.03	3,324,941.75	8,888,700.78	155,287,090.52	68,846,153.74	239,111,875.82

Table (38-A)

Weighted Average Household Productivity loss per RTA Injury in the UAE during 1995

(Value in AED)

AIS Category	Average Household Productivity Loss per AIS
Minor Injury (AIS 1)	621.48
Moderate Injury (AIS 2)	1,860.62
Serious Injury (AIS 3)	3,709.08
Severe Injury (AIS 4)	215,676.51
Critical Injury (AIS 5)	203,086.00

Table (39)

Sensitivity Analysis of Household (HH) Productivity Losses from RTA Injuries per AIS Categories in the UAE during 1995 (using an Effective Discounting Rate of 6.772%)

(Value in AED)

Age Group	Productivity Losses from Minor RTA Injuries	Productivity Losses from Moderate RTA Injuries	Productivity Losses from Serious RTA Injuries	Productivity Losses from Severe RTA Injuries	Productivity Losses from Critical RTA Injuries	Total Productivity Losses from RTA Injuries
0-1	-	-	-	7,407,098.48	-	7,407,098.48
1-4	106,751.44	77,050.19	441,784.77	7,054,379.51	-	7,679,965.91
5-9	79,143.31	146,762.27	445,435.88	7,230,739.00	-	7,902,080.46
10-14	27,608.13	146,762.27	511,155.93	3,527,189.75	-	4,212,716.08
15-19	161,354.19	521,006.06	1,113,589.70	10,757,928.75	5,290,784.63	17,844,663.33
20-24	722,106.00	519,171.53	890,871.76	14,105,218.51	4,988,430.94	21,225,798.74
25-29	454,000.37	225,646.99	1,475,049.97	13,610,847.14	10,291,128.32	26,056,672.79
30-34	508,603.12	146,762.27	1,339,958.76	25,849,643.44	19,071,993.02	46,916,960.61
35-39	295,713.76	671,437.38	744,827.21	29,640,087.72	8,906,627.34	40,258,693.41
40-44	133,746.06	223,812.46	744,827.21	10,392,009.12	2,727,902.39	14,222,297.24
45-49	54,602.75	75,215.66	295,740.22	-	4,301,779.14	4,727,337.77
50-54	79,143.31	374,243.79	149,695.67	-	-	603,082.77
55-59	27,608.13	73,381.13	445,435.88	-	-	546,425.14
60 +	79,143.31	77,050.19	149,695.67	-	-	305,889.17
Total	2,729,523.87	3,278,302.19	8,748,068.63	129,575,141.42	55,578,645.79	199,909,681.90

Table (39-A)

Weighted Average Household Productivity losses from RTA Injuries per AIS Categories in the UAE during 1995

(Value in AED)

AIS Injury Scale	Average Household Productivity Loss per AIS
Minor Injury (AIS 1)	613.51
Moderate Injury (AIS 2)	1,834.53
Serious Injury (AIS 3)	3,651.1
Severe Injury (AIS 4)	158,987.90
Critical Injury (AIS 5)	152,688.59

Table (40)
Sensitivity Analysis of Household Productivity Losses from RTA Injuries in the UAE during 1995 (using an effective discounting rate of 3.858%)
(Value in AED)

Age Group	Productivity Losses from Minor RTA Injuries	Productivity Losses from Moderate RTA Injuries	Productivity Losses from Serious RTA Injuries	Productivity Losses from Severe RTA Injuries	Productivity Losses from Critical RTA Injuries	Total Productivity Losses from RTA Injuries
0-1	-	-	-	11,112,548.18	-	11,112,548.18
1-4	108,326.45	78,295.06	449,851.49	10,583,379.22	-	11,219,852.22
5-9	80,310.99	149,133.44	453,569.27	10,847,963.70	-	11,530,977.40
10-14	28,015.46	149,133.44	520,489.33	5,291,689.61	-	5,989,327.84
15-19	163,734.81	529,423.71	1,133,923.19	16,139,653.31	7,937,534.42	25,904,269.44
20-24	732,759.97	527,559.54	907,138.55	20,591,238.64	7,282,267.32	30,040,964.02
25-29	460,698.70	229,292.66	1,501,983.50	19,256,366.37	14,559,691.64	36,008,032.87
30-34	516,107.06	149,133.44	1,364,425.60	35,286,694.69	26,034,695.47	63,351,056.26
35-39	300,076.72	682,285.49	758,427.31	38,852,774.71	11,674,971.71	52,268,535.94
40-44	135,719.35	227,428.50	758,427.31	13,013,622.71	3,416,075.96	17,551,273.83
45-49	55,408.36	76,430.89	301,140.26	-	5,118,506.14	5,551,485.65
50-54	80,310.99	380,290.27	152,429.02	-	-	613,030.28
55-59	28,015.46	74,566.72	453,569.27	-	-	556,151.45
60 +	80,310.99	78,295.06	152,429.02	-	-	311,035.07
Total	2,769,795.32	3,331,268.20	8,907,803.12	180,975,931.15	76,023,742.67	272,008,540.46

Table (40-A)
Average Household Productivity loss from Injuries in UAE during 1995
(Value in AED)

AIS Category	Average Household Productivity Loss per AIS
Minor Injury (AIS 1)	622.57
Moderate Injury (AIS 2)	1,864.17
Serious Injury (AIS 3)	3,717.78
Severe Injury (AIS 4)	222,056.36
Critical Injury (AIS 5)	208,856.44

9.2.3 Unit Medical Costs of RTA Injuries

Based on the methods described in section (7.2.2.5) the study analysed the sample data of Al-Ain hospital to estimate the distribution of RTA injury outcomes in the UAE. The analysis revealed that of the total number of the sample cases (N=247): 3.3% were no injuries, 42.1% were minor injuries, 18.2% were moderate injuries, 24.4% were serious injuries, 8.3% were severe injuries, 2.5% were critical injuries and 1.2 were fatal injuries (Table 41).

Table (41)
Severity of Nonfatal RTA Injuries in the UAE during 1998

Age group	None	Minor injury	Moderate injury	Serious injury	Severe injury	Critical injury	Fatal injury	Total
0-1 years	1	0.0	0.0	0.0	0.0	0.0	0.0	1
%	12.5%	0.0	0.0	0.0	0.0	0.0	0.0	0.4%
1-4 years	1	4	1	3	1	0.0	0.0	10
%	12.5%	3.9%	2.3%	5.1%	5.0%	0.0	0.0	4.1%
5-9 years	0.0	3	0.0	4	2	0.0	0.0	9
%	0.0	2.9%	0.0	6.8%	10.0%	0.0	0.0	3.7%
10-14 years	0.0	1	2	0.0	0.0	0.0	0.0	3
%	0.0	1.0%	4.5%	0.0	0.0	0.0	0.0	1.2%
15-19 years	0.0	6	7	10	0.0	0.0	0.0	23
%	0.0	5.9%	15.9%	16.9%	0.0	0.0	0.0	9.5%
20-24 years	2	23	7	6	2	1	0.0	41
%	25.0%	22.5%	15.9%	10.2%	10.0%	16.7%	0.0	16.9%
25-29 years	0.0	13	3	10	2	0.0	0.0	28
%	0.0	12.7%	6.8%	16.9%	10.0%	0.0	0.0	11.6%
30-34 years	1	19	2	9	2	0.0	0.0	33
%	12.5%	18.6%	4.5%	15.3%	10.0%	0.0	0.0	13.6%
35-39 years	0.0	11	9	5	4	3	0.0	32
%	0.0	10.8%	20.5%	8.5%	20.0%	50.0%	0.0	13.2%
40-44 years	1	5	3	5	5	1	0.0	20
%	12.5%	4.9%	6.8%	8.5%	25.0%	16.7%	0.0	8.3%
45-49 years	0.0	2	1	2	2	0.0	2	9
%	0.0	2.0%	2.3%	3.4%	10.0%	0.0	66.7%	3.7%
50-54 years	1	3	5	1	0.0	1	0.0	11
%	12.5%	2.9%	11.4%	1.7%	0.0	16.7%	0.0	4.5%
55-59 years	0.0	1	1	3	0.0	0.0	0.0	5
%	0.0	1.0%	2.3%	5.1%	0.0	0.0	0.0	2.1%
60 + above	1	3	1	1	0.0	0.0	0.0	6
%	12.5%	2.9%	2.3%	1.7%	0.0	0.0	0.0	2.5%
Total	8	102	44	59	20	6	3	242
Overall %	3.3%	42.1%	18.2%	24.4%	8.3%	2.5%	1.2%	100.0%

The analysis of RTA injury outcomes after initial medical assessment at hospital (i.e. ER) revealed that 57.3% were discharged after basic treatment, 3%

transferred to the ICU, 38% to the medical wards, for further surgical or orthopaedic procedures, and 1.2% passed away (Table 42).

Table (42)
Nonfatal RTA Injury Outcomes in the UAE during 1998

Injury Severity	Discharge from ER	Admitted to ICU	Admitted to Ward	Dead	Total
Minor	98	0	0	0	98
%	73.1%	0	0	0	41.9%
Moderate	28	0	14	0	42
%	20.9%	0	15.6%	0	17.9%
Serious	0	0	57	0	57
%	0	0	63.3%	0	24.4%
Severe	0	2	18	0	20
%	0	28.6%	20.0%	0	8.5%
Critical	0	5	1	0	6
%	0	71.4%	1.1%	0	2.6%
Fatal	0	0	0	3	3
%	0	0	0	100.0%	1.3%
Total	134	7	90	3	234
%	57.3%	3.0%	38.5%	1.2%	100.0%

N= 234

Of those referred to the ICU, 87.5% received advanced therapeutic procedures and 12.5% received special procedures (Table 43). The analysis revealed that 57% passed away at the ICU and 43% were transferred to hospital wards. Of those transferred to hospital wards (AIS 2 to AIS 5), 50.5% received basic medical procedures, 41.8% advanced medical procedure and 7.6 special medical procedure (p=0.05) (Tables: 44 and 45). The analysis of RTA injury outcomes at hospital wards indicate that 92.4% were discharged home after successful treatment and 7.6% were transferred to specialised trauma hospitals for further medical treatment and rehabilitation (Table 46).

Table (43)
Medical Intervention for RTA Casualties at the ICU during 1998

Injury Assessment	Advanced Intervention	Special Intervention	%
Minor	14.3%	-	12.5%
Severe	28.6%	-	25.0%
Critical	57.1%	100.0%	62.5%
Total	100.0%	100.0%	100.0%

P = n.s..

Table (44)

Outcomes of RTA Injuries at the ICU during 1998

	Dead	Transferred to the ward	Total %
Minor	100.0%	-	100.0%
	25.0%	-	14.3%
Severe	-	100.0%	100.0%
	-	**66.7%**	28.6%
Critical	75.0%	25.0%	100.0%
	75.0%	**33.3%**	57.1%
Total	57.1%	42.9%	100.0%
	100.0%	**100.0%**	100.0%

P = N.S.

Table (45)

Medical Intervention for RTA Casualties at Hospital Wards during 1998

Injury Assessment	Basic Intervention	Advanced Intervention	Special Intervention	Total %
moderate	81.8%	18.2%	-	100.0%
	22.5%	6.1%	-	**13.9%**
Serious	57.1%	34.7%	8.2%	100.0%
	70.0%	51.5%	**66.7%**	**62.0%**
Severe	17.6%	76.5%	5.9%	100.0%
	7.5%	39.4%	**16.7%**	**21.5%**
Critical	-	50.0%	50.0%	100.0%
	-	3.0%	**16.7%**	**2.5%**
Total	**50.6%**	**41.8%**	**7.6%**	**100.0%**
	100.0%	**100.0%**	**100.0%**	**100.0%**

Table (46)

Outcomes of Nonfatal RTA Injuries at the Hospital Wards during 1998

Injury Assessment	Discharged	Transferred to another Hospital	%
Moderate	81.8%	18.2%	100.0%
	12.3%	**33.3%**	13.9%
Serious	93.9%	6.1%	100.0%
	63.0%	**50.0%**	62.0%
Severe	94.1%	5.9%	100.0%
	21.9%	**16.7%**	21.5%
Critical	100.0%	-	100.0%
	2.7%	-	2.5%
Total	92.4%	7.6%	100.0%
	100.0%	**100.0%**	100.0%

The analysis of the number of hospital days spent at hospital wards indicate that 62.7% of casualties spent less than 5 hospital bed days, 9.6% less than 10 bed days, 9.6% less than 15 days, 8.4%less than 30 days and 9.7% less than 3 month (p=0.05) (Table 47).

Table (47)
Hospital Bed-days due to Nonfatal RTA Injuries in the UAE during 1998

Injury Assessment	0-5 days	6-10 days	11-15 days	16-20 days	21-25 days	26-30 days	31-90 days	Total
Moderate	81.8%	-	9.1%	9.1%	-	-	-	100.0%
Serious	73.1%	7.7%	9.6%	3.8%	-	1.9%	3.8%	100.0%
Severe	29.4%	23.5%	11.8%	5.9%	5.9%	11.8%	11.8%	100.0%
Critical	-	-	-	100.0%	-	-	-	100.0%
Total	62.7%	9.6%	9.6%	8.4%	1.2%	3.6%	4.8%	100.0%

N=247

The analysis of medical costs of RTA injuries per AIS category, using the Al-Ain hospital sample of 1998, gave a mean value of AED 2,316 (SD=59.6) for minor injuries, AED 11,801 (SD= 13012.29) for moderate injuries, AED 39,112 (SD=19,252) for serious injuries, AED 45,609 (SD=34,351) for severe injuries and AED 78,462 (SD=1716) for critical injuries (Table 48).

Table (48)
Inpatient Medical Costs per AIS in the UAE during 1998
(Value in AED)

Injury Assessment	Parameter		Statistic	Std. Error
Minor	**Mean**		**2315.9498**	**5.9043**
	95% C.I. for Mean	Lower Bound	2304.2374	
		Upper Bound	2327.6623	
	Median		2311.7160	
	Std. Deviation		59.6300	
	Minimum		2100.00	
	Maximum		2867.00	
Moderate	**Mean**		**11801.4154**	**1961.6772**
	95% C.I. for Mean	Lower Bound	7845.3162	
		Upper Bound	15757.5145	
	Median		5133.7160	
	Std. Deviation		13012.2946	
	Minimum		5133.72	
	Maximum		57551.87	
Serious	**Mean**		**39112.0703**	**2506.4187**
	95% C.I. for Mean	Lower Bound	34094.9282	
		Upper Bound	44129.2124	
	Median		34917.7680	
	Std. Deviation		19252.1671	
	Minimum		5133.72	
	Maximum		102820.1	
Severe	**Mean**		**45609.7769**	**6736.8675**
	95% C.I. for Mean	Lower Bound	31734.9385	
		Upper Bound	59484.6153	
	Median		53003.4680	
	Std. Deviation		34351.4190	
	Minimum		5133.72	
	Maximum		115402.9	
Critical	**Mean**		**78462.3347**	**990.4667**
	95% C.I. for Mean	Lower Bound	74200.7006	
		Upper Bound	82723.9688	
	Median		77471.8680	
	Std. Deviation		1715.5386	
	Minimum		77471.87	
	Maximum		80443.27	

The above proportions and parameters were applied to the nonfatal RTA injury data of 1995 to estimate the distribution of outcomes of RTA injuries per AIS categories during that year. Table (28) shows the estimated distribution of RTA injuries according to AIS categories and tables (49 and 50) show the medical outcomes of RTA injuries per AIS categories during 1995.

Table (49)

Outcomes of RTA Injuries at Emergency Rooms (ER) in Hospitals in the UAE during 1995

Type of Injury	Discharged from ER	Admitted to ICU	Admitted to Ward	Dead	Total
Minor	4449	-	-	-	4449 (45.3%)
Moderate	1192	-	595	-	1787 (17.9%)
Serious	-	-	2396	-	2396 (24.4%)
Severe	-	82	733	-	815 (8.5%)
Critical	-	186	51	127	364 (3.9%)
Total	5641	268	3775	127	9811* (100%)

* The difference with the total number of nonfatal RTA injuries during 1995 (9691) was due to rounding.

Table (50)

Outcomes of RTA Injuries at Hospital Wards in the UAE during 1995

Type of Injury	Dead	Discharged	Transferred to another hospital	Total
Moderate Injury	0	487	108	595
		81.8%	18.2	100%
Serious Injury	0	2250	146	2396
		93.9%	6.1%	100%
Severe Injury	0	765	40	815
		94%	6%	100%
Critical Injury	127	237	0	364
	35%	65%		100%
Total	127	3793	294	4170
	3%	91%	7%	100%

Tables (51-55) show estimated medical interventions and hospital bed days from RTA injuries per AIS categories during 1995.

Table (51)

Medical Intervention for RTA Injuries at the ICU in the UAE during 1995

Injury Assessment	Advanced Intervention	Special Intervention
Severe	815	-
Critical	364	-
Total	1179	-

Table (52)
Medical Intervention for RTA Casualties at Hospital Wards during 1998

Injury Assessment	Basic Intervention	Advanced Intervention	Special Intervention	**Total** (%)
Moderate	1462	325	-	1787
	22.5%	6.1%	-	13.9%
Serious	1368	832	196	2396
	70.0%	51.5%	66.7%	62.0%
Severe	143	624	48	815
	7.5%	39.4%	16.7%	21.5%
Critical	-	182	182	364
	-	3.0%	16.7%	2.5%
Total	**2973**	**1963**	**426**	**5362**
	100.0%	100.0%	100.0%	100.0%

Table (53)
Outcomes of RTA Injuries per AIS Categories at Hospital Wards in the UAE during 1995

AIS Category	Discharged	Transferred to another Hospital	Total (%)
Moderate	1462	325	1787
	12.3%	33.3%	13.9%
Serious	2250	146	2396
	63.0%	50.0%	62.0%
Severe	767	48	815
	21.9%	16.7%	21.5%
Critical	364	-	364
	2.7%	-	2.5%
Total	**4843**	**519**	**5362**
	100.0%	100.0%	100.0%

Table (54)
Hospital Bed-days due to RTA Injuries in the UAE During 1995

Injury Assessment	0-5 days	6-10 days	11-15 days	16-20 days	21-25 days	26-30 days	31-90 days	Total
Moderate	1462		163	162	-	-	-	1787
Serious	1751	186	230	91	-	46	92	2396
Severe	240	192	95	48	47	97	96	815
Critical	-	-	-	224	29	43	67	364
Total	**3453**	**873**	**488**	**525**	**76**	**186**	**255**	**5362**

Table (55)
Medical Costs due to RTA Injuries in the UAE During 1995
(Value in AED)

Age Group	Medical Costs of Minor Injuries	Medical Costs of Moderate Injuries	Medical Costs of Serious Injuries	Medical costs of Severe Injuries	Medical Costs of Critical Injuries	Total Medical Costs from RTA Injuries
0-1	0.00	0.00	0.00	1,915,610.63	0.00	1,915,610.63
1-4	402,973.56	495,659.64	4,732,560.47	1,824,391.08	0.00	7,455,584.75
5-9	298,756.26	944,113.60	4,771,672.54	1,870,000.85	0.00	7,884,543.25
10-14	104,217.30	944,113.60	5,475,689.80	912,195.54	0.00	7,436,216.24
15-19	609,092.22	3,351,603.28	11,929,181.35	2,782,196.39	2,353,870.04	21,025,943.28
20-24	2,725,861.38	3,339,801.86	9,543,345.08	3,740,001.71	2,275,407.71	21,624,417.73
25-29	1,713,795.60	1,451,574.66	15,801,276.28	3,740,001.71	4,864,664.75	27,571,313.00
30-34	1,919,914.26	944,113.60	14,354,129.69	7,480,003.41	9,493,942.50	34,192,103.46
35-39	1,116,283.08	4,319,319.72	7,978,862.28	9,258,784.71	4,786,202.42	27,459,452.21
40-44	504,874.92	1,439,773.24	7,978,862.28	3,648,782.15	1,647,709.03	15,220,001.62
45-49	206,118.66	483,858.22	3,168,077.67	0.00	3,138,493.39	6,996,547.94
50-54	298,756.26	2,407,489.68	1,603,594.87	0.00	0.00	4,309,840.81
55-59	104,217.30	472,056.80	4,771,672.54	0.00	0.00	5,347,946.64
60 +	298,756.26	495,659.64	1,603,594.87	0.00	0.00	2,398,010.77
Total	10,303,617.06	21,089,137.54	93,712,519.72	37,171,968.17	28,560,289.83	190,837,532.32

As shown in table (55) the direct hospital inpatient treatment costs of minor nonfatal RTA injuries in the UAE amounted to AED 10 millions, moderate injuries amounted to AED 21 millions, serious injuries amounted to AED 94 million, severe injuries amounted to AED 37 millions, critical injuries amounted to AED 29 millions and overall medical costs due to RTA injuries amounted to AED 191 millions.

Sensitivity analysis was performed using the lower and upper bound 95% confidence intervals of the mean medical cost per RTA injury per AIS category (Table 48). The results of sensitivity analysis are presented in tables (56 and 57).

Table (56)
Estimates of Medical Costs of RTA Injuries per AIS Category during 1995
(Using the lower bound confidence interval of the mean cost per AIS)
(Value in AED)

Age Group	Medical Costs of Minor Injuries	Costs of moderate Injuries	Medical Costs of Serious Injuries	Medical costs of Severe Injuries	Medical Costs of Critical Injuries	Total Medical Costs from RTA Injuries
0-1	0.00	0.00	0.00	1,332,867.42	0.00	1,332,867.42
1-4	400,896.00	329,503.28	4,125,486.31	2,968,000.00	0.00	7,823,885.59
5-9	297,216.00	627,625.30	4,159,581.24	1,301,132.48	0.00	6,385,555.01
10-14	103,680.00	627,625.30	4,773,289.95	634,698.77	0.00	6,139,294.01
15-19	605,952.00	2,228,069.80	10,398,953.10	1,935,831.25	2,226,021.02	17,394,827.17
20-24	2,711,808.00	2,220,224.48	8,319,162.48	2,602,264.96	2,151,820.32	18,005,280.24
25-29	1,704,960.00	964,973.89	13,774,350.99	2,602,264.96	4,600,443.44	23,646,993.28
30-34	1,910,016.00	627,625.30	12,512,838.65	5,204,529.91	8,978,284.77	29,233,294.63
35-39	1,110,528.00	2,871,385.73	6,955,365.35	6,442,192.52	4,526,242.74	21,905,714.33
40-44	502,272.00	957,128.58	6,955,365.35	2,538,795.08	1,558,214.71	12,511,775.72
45-49	205,056.00	321,657.96	2,761,689.18	0.00	2,968,028.02	6,256,431.17
50-54	297,216.00	1,600,444.50	1,397,892.06	0.00	0.00	3,295,552.56
55-59	103,680.00	313,812.65	4,159,581.24	0.00	0.00	4,577,073.89
60 +	297,216.00	329,503.28	1,397,892.06	0.00	0.00	2,024,611.34
Total	10,250,496.	14,019,580.	81,691,447.97	25,863,974.88	27,009,055.02	158,834,553.91

The results of sensitivity analysis, using the lower bound confidence interval of the mean medical hospital inpatient costs per AIS category (Table 56), show that the cost of minor RTA injuries amounted to AED 10 million, moderate RTA injuries amounted to AED 14 millions, serious injuries amounted to AED 82 millions, critical injuries amounted to AED 26 millions, critical injuries amounted to AED 27 millions and the overall medical costs of RTA injuries amounted to AED 159 millions.

Table (57)
Medical Costs of RTA Injuries per AIS categories during 1995
(Using the upper bound confidence interval of the mean cost per AIS)
(Value in AED)

Age Group	Medical Costs of Minor Injuries	Medical Costs of Moderate Injuries	Medical Costs of Serious Injuries	Medical costs of Severe Injuries	Medical Costs of Critical Injuries	Total Medical Costs from RTA Injuries
0-1	0.00	0.00	0.00	2,498,353.84	0.00	2,498,353.84
1-4	405,013.24	661,815.61	5,339,634.70	2,379,384.61	0.00	8,785,848.16
5-9	300,268.44	1,260,601.16	5,383,763.91	2,438,869.23	0.00	9,383,502.74
10-14	104,744.80	1,260,601.16	6,178,089.74	1,189,692.31	0.00	8,733,128.01
15-19	612,175.18	4,475,134.12	13,459,409.78	3,628,561.53	2,481,719.06	24,656,999.68
20-24	2,739,658.53	4,459,376.60	10,767,527.83	4,877,738.45	2,398,995.10	25,243,296.51
25-29	1,722,470.10	1,938,174.28	17,828,201.81	4,877,738.45	5,128,886.07	31,495,470.72
30-34	1,929,632.05	1,260,601.16	16,195,420.95	9,755,476.91	10,009,600.22	39,150,731.29
35-39	1,121,933.23	5,767,250.31	9,002,359.33	12,075,376.91	5,046,162.10	33,013,081.87
40-44	507,430.38	1,922,416.77	9,002,359.33	4,758,769.22	1,737,203.34	17,928,179.05
45-49	207,161.94	646,058.09	3,574,466.20	0.00	3,308,958.75	7,736,645.00
50-54	300,268.44	3,214,532.96	1,809,297.71	0.00	0.00	5,324,099.10
55-59	104,744.80	630,300.58	5,383,763.91	0.00	0.00	6,118,809.30
60 +	300,268.44	661,815.61	1,809,297.71	0.00	0.00	2,771,381.75
Total	10,355,769.57	28,158,678.41	105,733,592.91	48,479,961.47	30,111,524.64	222,839,527.01

The results of sensitivity analysis, using the upper bound confidence interval of the mean medical cost per AIS category (Table 57), show that medical costs of minor nonfatal RTA injuries amounted to AED 10 million, moderate injuries amounted to AED 28 millions, serious injuries amounted to AED 106 millions, severe injuries amounted to AED 48 millions, critical injuries amounted to AED 30 millions and the overall medical costs of nonfatal RTA injuries amounted to AED 223 millions.

1. Unit cost of police response	AED 1,740.00
2. Unit cost of Fire response	AED 1,907.10
Total police and fire response cost per RTA	AED 3647.10
3. Average cost of police and fire response per casualty	AED 2096.00
4. Unit cost of EMS = (AED 801.92*0.061)	AED 48.90
Average Unit Cost per RTA injury	**AED 2,144.90**

9.2.5 **Legal Costs of RTA Injuries in the UAE during 1995**

The study used the model described in the methods chapter (section 7.2.2.8) to compute legal and court costs of RTA injuries. To achieve that the study used the data from Annual Insurance Statistics (UAE-AIS, 1988-1992) to compute the average compensation per RTA injury in the UAE during 1995. The analysis revealed the following:

1. **For 3rd Party Insurance Policies:**

a. Compensation for Human damages	AED 4,012,645.50
b. Compensation for Material Damages	AED 69,788,794.00

2. **For Comprehensive insurance policies:**

a. Compensation for human damages:	AED 6,595,770.00
b. Compensation for Material damages	AED 241,788,794.00
Total	AED 341,499,800.50
Total number of nonfatal RTA injuries in 1995	9691

3. **Average compensation =** **AED 35,238**

The study used the average compensation for RTA injuries as a proxy to compute legal attorney fees. Other variables of the model were estimated from different sources, as follows:

$$TLC_{RTAs} = E_{cas.} [RTA_{comp} (CF+CME) + RTA_{3p} (AF+CF+CME)] + AP_{cas.} [RTA_{comp} (CF+CME) + RTA_{3p} (CF+CME)].$$

$E_{cas.} = 0.75$

AP_{cas} = 0.25

RTA_{comp} = 0.45

AF = 0.125 X AED 34,776 = AED 4,347

CF = AED 1000

CME = AED 750

RTA_{3p} = 0.55.

Replacing the variables, the model becomes:

0.75[0.45(1000+750)+0.55(4347+1000+750)]+0.25[0.45(1000+750)+0.5 5(1000+750)] = **AED 2,667.4**

The Unit cost of legal and court administration of RTA injury per AIS was found to equal AED 2,667.40 during 1995.

9.2.6 **Insurance Administration Cost of RTA Injuries during 1995**

Based on the assumptions and methods described in section (7.2.2.7) the study estimated the unit cost of insurance administration of RTA injuries per AIS categories to be equivalent to the estimate calculated in section (9.1.6.) for RTA fatalities (i.e. AED 1604.20).

9.2.7 **Employer/Work Place Cost due to RTA Injuries during 1995**

Based on the methods described in section (7.2.2.9), the results of the sample of employment contracts obtained from Employment Agents in Al-Ain, the assumptions made in section (7.2.1.0.) and the results of the analysis of Al-Ain hospital data on disability due to RTA injuries (section 7.2.2.1) the study estimated employer / workplace costs from RTA injuries to be as follows:

1. Workplace production downtime due to work disruption from RTA injuries per AIS categories, was estimated on the basis of the days of absence from work due to RTAs, estimated in section (7.2.2.1), as follows:

Severity of Injury (AIS)	Work days absence/weeks
No injury	2 days
Minor injury (AIS1)	2 weeks
Moderate injuries	6 weeks
Serious injuries	12 weeks
Severe Injuries	Life disabling
Critical injuries	Life disabling

2. To estimate workplace production losses the study used the average hourly earnings per labourer in the UAE during 1995 (AED 17.4), to calculate these costs. The results were as follows:

Injury Severity (AIS)	Cost per AIS (in AED)
No injury	278.40
Minor injury (AIS1)	1,948.80
Moderate injuries	5,846.40
Serious injuries	11,692.80
Severe Injuries	38,100.00
Critical injuries	38,100.00

Critical and severe injuries were assumed to be totally disabling, therefore, requiring full replacement similar to RTA fatalities. Hence, the study used the estimation made in section (7.2.1.0.) for RTA fatalities.

3. The average administrative expenditure for recruiting replacements for life disabled victims (AIS 4 and 5) were similar to the estimate made for RTA fatalities (i.e. AED 2,342.87), and therefore the same estimate was used for RTA injuries.

4. Thus, workplace/employer costs from RTA injuries during 1995 were estimated to be as follows:

Injury Severity (AIS)	Costs per AIS (in AED)
No injury	278.40
Minor injury (AIS1)	1,948.80
Moderate injuries	5,846.40
Serious injuries	11,692.8
Severe Injuries	40,442.87
Critical injuries	40,442.87

9.3 Property Damage Costs of RTAs

9.3.1 Property Damage Costs of RTAs in the UAE during 1995

Based on the methods described in section (7.2.3) the data from the Annual Insurance Statistics report (UAE-AIS, 1992) for comprehensive insurance policies indicates that the average incurred loss from a property damage comprehensive RTA claim during 1992 was AED 3,807.38. In the UAE, comprehensive insurance RTA claims are subject to a deductible, which average an amount of AED 300 per vehicle. Adjusting for this, the average incurred loss from a property damage comprehensive RTA claim becomes AED 4,107.38. The data for third party insurance policies indicates that the average incurred loss from a property damage third party RTA claim was AED 2,865.35. The data in section (9.1.6) indicate that third party insurance policies account for 55% of RTA claims and comprehensive insurance policies account for 45% of RTA claims in the UAE during the period 1988-1992. Weighting the average property damage costs by the proportion of each policy type yields an average property damage cost per insured RTA claim of AED 3,424.26. Factoring this average to the rates of 1995, using the CPI rate of 4.2%, yields an average property damage cost per insured RTA claim of AED 3,874.09 for 1995. The study used the resulting figure as an estimate for the unit cost of property damage per RTA per AIS category.

9.3.2 The Cost of Property Damage Only Crashes (PDO) in the UAE

Based on the methods described in section (7.2.3.2) the study estimated the costs of property damages as follows:

1. Workplace and household productivity losses per PDO were based on the average workdays' absence due to RTAs, estimated in section (7.2.2.1.) and the hourly earnings in the UAE during 1995.
2. Insurance and emergency services costs (police and fire service costs) calculated in sections (9.2.4. and 9.2.6) were used for the estimation.
3. Average unit costs of PDOs were similar to the estimate drawn in the previous section, i. e. AED 3,874.09.

Thus, the average PDO cost was estimated to be:

1.	Workplace and household productivity losses	AED 278.40
2.	Unit cost of police and fire response per casualty	AED 1823.55
3.	Unit cost of EMS = (AED 801.92*0.061)	AED 48.90
4.	Insurance administration cost	AED 1,604.00
5.	Legal and court cost	AED 200.00
6.	Workplace cost	AED 104.00
7.	PDO cost	AED 3,874.09
	Average PDO Cost	**AED 7,932.45**

9.4 Summary Unit Costs of RTAs in the UAE during 1995

Based on the unit cost estimates produced in the preceding sections, a summary of the average unit RTA costs per AIS is made for three scenarios: the expected, using the mean rates and the mean medical cost estimates; the optimistic values, using the upper bound effective discounting rate and lower bound confidence intervals for medical costs; and the pessimistic values, calculated using the lower bound effective discounting rates and the upper bound confidence intervals for medical costs. Accordingly, Table (58) summarises the expected estimates of unit cost components of RTA fatalities and injuries per AIS category in the UAE during 1995.

Table (58)
Summary of Unit RTA Cost Components in the UAE during 1995
(The Expected Values using the Mean Rates)

Component	PDO per vehicle	AIS 1	AIS 2	AIS 3	AIS 4	AIS 5	Fatal
Productivity loss	206	3557	10859	21270	1311045	1232733	1282486
Medical cost	0	2316	11801	39112	45610	78462	7644
Premature funeral	0	0	0	0	0	0	6,032
Household production	72	621	1,861	3,709	215676	203086	234926
Emergency services	1872.45	2144	2144	2144	2144	2144	4,449
Insurance administration	1,604	1,604	1,604	1,604	1,604	1,604	1,604
Legal / court cost	200	2667	2667	2667	2667	2667	20,500
Workplace cost	104	1,949	5,846	11,693	40442	40442	40442
Property damage	3,874	3,874	3,874	3,874	3,874	3,874	3,874
Total	7,932.45	18,733	40,658	86,076	1,623,066	1,565,017	1,601,957

Table (59) summarises the optimistic estimates of unit cost components RTA fatalities and injuries per AIS category in the UAE during 1995.

Table (59)
Summary of Unit RTA Cost Components in the UAE during 1995
(The Optimistic Scenario)

Component	PDO per vehicle	AIS 1	AIS 2	AIS 3	AIS 4	AIS 5	Fatal
Productivity loss	206	3510	10701	18588	961921	924277	946639
Medical cost	0	2304	7845	34095	31734	74200	7644
Premature funeral	0	0	0	0	0	0	6,032
Household production	72	614	1835	3651	158988	152689	151055
Emergency services	1872.45	2144	2144	2144	2144	2144	4,449
Insurance administration	1,604	1,604	1,604	1,604	1,604	1,604	1,604
Legal / court cost	200	2667	2667	2667	2667	2667	20,500
Workplace cost	104	1,949	5,846	11,693	40442	40442	40442
Property damage	3,874	3,874	3,874	3,874	3,874	3,874	3,874
Total	7,932.45	18,667	36,518	78,319	1,203,378	1,201,902	1,182,239

Table (60) summarises the pessimistic estimates of unit cost components of RTA fatalities and injuries per AIS category in the UAE during 1995.

Table (60)
Summary of Unit RTA Costs in the UAE during 1995
(The Pessimistic Scenario)

Component	PDO per vehicle	AIS 1	AIS 2	AIS 3	AIS 4	AIS 5	Fatal
Productivity losses	206	3561	10873	21302	1352042	1268744	1344415
Medical cost	0	2328	15757	44129	59485	82724	7644
Premature funeral	0	0	0	0	0	0	6,032
Household production	72	623	1,864	3,718	222,056	208,856	247500
Emergency services	1872.45	2144	2144	2144	2144	2144	4,449
Insurance administration	1,604	1,604	1,604	1,604	1,604	1,604	1,604
Legal / court cost	200	2667	2667	2667	2667	2667	20,500
Workplace cost	104	1,949	5,846	11,693	40442	40442	40442
Property damage	3,874	3,874	3,874	3,874	3,874	3,874	3,874
Total	7,932.45	18,751	44,631	91,134	1,684,318	1,611,060	1,676,460

9.5 Summary Total Costs of RTAs in the UAE during 1995

Based on the unit cost estimates shown in Tables (58, 59 and 60), the numbers of RTA casualties and PDO damages, the study calculated thee possible estimates for the total cost of RTAs in the UAE during 1995: the expected, the optimistic and the pessimistic costs. Accordingly, three possible estimates were produced for the total cost of RTAs in the UAE during 1995: an expected estimate amounting to AED 3.8 billions (Table 61), an optimistic estimate amounting to AED 3.1 billions (Table 62) and a pessimistic estimate amounting to AED 4 billions.

Table (61)
Summary of Total Costs of RTAs in the UAE during 1995
(Using an effective discounting rate equivalent to 4.2%)
(Value in AED)

RTA Cost Components	Minor	Moderate	Serious	Severe	Critical	Fatal	PDO	Total
Direct RTA Costs:								
1- Medical Care	10,303,617	21,089,138	93,712,520	37,171,968	28,560,290	5,268,000	0	196,105,532
2- Premature Funeral	0	0	0	0	0	3,398,335	0	3,398,335
3- Emergency Services	9,534,525	3,755,895	5,139,420	1,544,400	727,155	4,653,360	152,190,864	177,545,619
4- Insurance administration	7,129,780	2,808,604	3,843,184	1,154,880	543,756	1,106,760	130,371,516	146,958,480
5- Legal and court admin.	11,854,815	4,669,917	6,390,132	1,920,240	904,113	14,145,000	16,255,800	56,140,017
6- Work place costs	8,663,305	10,236,346	28,016,428	29,118,240	13,709,838	27,904,980	8,453,016	126,102,153
7- Property damages	17,219,930	6,783,374	9,282,104	2,789,280	1,313,286	2,673,060	314,874,846	354,935,880
Subtotal *(Direct Costs)*	**64,705,972**	**49,343,274**	**146,383,788**	**73,699,008**	**45,758,438**	**59,149,495**	**622,146,042**	**1,061,186,016**
Indirect RTA Costs:								
8- Workplace Productivity	15,811,688	19,014,709	50,836,439	943,512,737	417,896,407	885,176,906	22,595,562	2,354,844,448
9- Household Productivity	2,764,989	3,324,942	8,888,701	155,287,091	68,846,154	162,135,340	5,852,088	407,099,304
Subtotal *(Indirect Costs)*	**18,576,677**	**22,339,651**	**59,725,140**	**1,098,799,828**	**486,742,561**	**1,047,312,246**	**28,447,650**	**2,761,943,752**
Total RTA Costs	**83,282,649**	**71,682,924**	**206,108,928**	**1,172,498,836**	**532,500,999**	**1,106,461,741**	**650,593,692**	**3,823,129,768**

Table (62)
Summary of Total Costs of RTAs in the UAE during 1995
(Using an effective discounting rate equivalent to 6.8%)
(Value in AED)

RTA Cost Components	Minor	Moderate	Serious	Severe	Critical	Fatal	PDO	Total
Direct RTA Costs:								
1- Medical Care	10,250,496	14,019,580	81,691,448	25,863,975	27,009,055	5,268,000	0	164,102,554
2- Premature Funeral	0	0	0	0	0	3,398,335	0	3,398,335
3- Emergency Services	9,534,525	3,755,895	5,139,420	1,544,400	727,155	4,653,360	152,190,864	177,545,619
4- Insurance administration	7,129,780	2,808,604	3,843,184	1,154,880	543,756	1,106,760	130,371,516	146,958,480
5- Legal and court admin.	11,854,815	4,669,917	6,390,132	1,920,240	904,113	14,145,000	16,255,800	56,140,017
6- Work place costs	8,663,305	10,236,346	28,016,428	29,118,240	13,709,838	27,904,980	8,453,016	126,102,153
7- Property damages	17,219,930	6,783,374	9,282,104	2,789,280	1,313,286	2,673,060	314,874,846	354,935,880
Subtotal *(Direct Costs)*	**64,652,851**	**42,273,716**	**134,362,716**	**62,391,015**	**44,207,203**	**59,149,495**	**622,146,042**	**1,029,183,038**
Indirect RTA Costs:								
8- Workplace Productivity	15,831,140	19,040,314	50,913,754	690,561,079	312,469,389	646,987,322	22,595,562	1,758,398,560
9- Household Productivity	2,729,144	3,277,803	8,746,566	129,202,820	55,427,580	114,868,565	5,852,088	320,104,566
Subtotal *(Indirect Costs)*	**18,560,284**	**22,318,117**	**59,660,320**	**819,763,899**	**367,896,969**	**761,855,887**	**28,447,650**	**2,078,503,126**
Total RTA Costs	**83,213,135**	**64,591,833**	**194,023,036**	**882,154,914**	**412,104,172**	**821,005,382**	**650,593,692**	**3,107,686,209**

Table (63)
Summary of Total Costs of RTAs in the UAE during 1995
(Using an effective discounting rate equivalent to 3.8%)
(Value in AED)

RTA Cost Components	Minor	Moderate	Serious	Severe	Critical	Fatal	PDO	Total
Direct RTA Costs:								
1- Medical Care	10,355,770	28,158,678	105,733,593	48,479,961	30,111,525	5,268,000	0	228,107,527
2- Premature Funeral	0	0	0	0	0	3,398,335	0	3,398,335
3- Emergency Services	9,534,525	3,755,895	5,139,420	1,544,400	727,155	4,653,360	152,190,864	177,545,619
4- Insurance administration	7,129,780	2,808,604	3,843,184	1,154,880	543,756	1,106,760	130,371,516	146,958,480
5- Legal and court admin.	11,854,815	4,669,917	6,390,132	1,920,240	904,113	14,145,000	16,255,800	56,140,017
6- Work place costs	8,663,305	10,236,346	28,016,428	29,118,240	13,709,838	27,904,980	8,453,016	126,102,153
7- Property damages	17,219,930	6,783,374	9,282,104	2,789,280	1,313,286	2,673,060	314,874,846	354,935,880
Subtotal *(Direct Costs)*	**64,758,125**	**56,412,814**	**158,404,861**	**85,007,001**	**47,309,673**	**59,149,495**	**622,146,042**	**1,093,188,011**
Indirect RTA Costs:								
8- Workplace Productivity	15,831,139	19,040,314	50,913,754	973,470,673	430,104,424	927,927,984	22,595,562	2,439,883,850
9- Household Productivity	2,769,795	3,331,268	8,907,803	180,975,931	76,023,742	170,814,560	5,852,088	448,675,187
Subtotal *(Indirect Costs)*	**18,600,934**	**22,371,582**	**59,821,557**	**1,154,446,604**	**506,128,166**	**1,098,742,544**	**28,447,650**	**2,888,559,037**
Total RTA Costs	**83,359,059**	**78,784,396**	**218,226,418**	**1,239,453,605**	**553,437,839**	**1,157,892,039**	**650,593,692**	**3,981,747,048**

As shown in the tables above the total economic cost of RTA fatalities, injuries and property damages in the UAE during 1995 totalled AED 3-4 billions (equivalent to US$ 1 billion), which represents 2-3% of the annual GDP in the UAE during 1995 (AED 141 billions). Of this amount, workplace productivity losses were responsible for 62%, household productivity losses for 11%, property damage costs for 9%, emergency services (police, fire and ambulance) were responsible for 5%, medical costs for 5% and employer workplace related cost for 3% (Table 64).

Table (64)

Percentage Distribution of RTA Costs in the UAE during 1995

RTA Cost Component	Total Cost	% of Total Cost
Productivity losses	2,354,844,448	61.6
Medical costs	196,105,532	5.1
Premature Funeral cost	3,398,335	0.1
HH productivity loss	407,099,304	10.6
Emergency services cost	177,545,619	4.6
Insurance administration	146,958,480	3.8
Legal cost	56,140,017	1.5
Workplace cost	126,102,153	3.3
Property damage cost	354,935,880	9.3
Total	3,823,129,768	100.0

9.6 Comprehensive Cost of RTAs in the UAE during 1995

To determine the value of statistical life in the UAE the study adapted Miller's estimate for the value of life in the US during 1993 for the UAE after adjustment.

To adjust 1993 Miller's figure ($ 2.2 million per fatal injury) for the UAE's rates in 1995, firstly, the study used the UAE's CPI (All Items) to upgrade the figure to the rates of 1995. Secondly, using times series analysis, a special index was calculated by dividing the per capita income in the UAE by that of the US over the 1990s. The resulting ratio was used to account for the differential in 'perceived utility preference towards safety' between the US and the UAE. Time series analysis yielded a ratio of 0.60 (implying a 40% differential in the UAE compared to the US). Applying that ratio to Miller's estimate the study yielded a value of statistical life equivalent to $ 1.6 million in the UAE during 1995 (equivalent to AED 5.9 million).

To calculate estimates for reduced quality of life for other categories of nonfatal injury in the UAE the study used an index suggested by Elvik (1993) estimating decreases in quality of life pertaining to RTA injury, along AIS categories, to be proportional to the number of 'lost years of living with perfect health' caused by these injuries. The losses were based on the results of a detailed sample survey of the daily life of RTA injury victims. A severe injury for example was graded to cause 8% loss in case of a fatal injury (Elvik, 1993). Using the index the costs of lost quality of life for all AIS nonfatal RTA injury categories were calculated.

To determine estimates for pain grief and suffering for the UAE the study again adapted the procedure laid by Miller (1993), deducting the monetary components of nonfatal RTAs from the WTP estimate, leaving behind a "pure" lost quality of life cost in the UAE.

To calculate the comprehensive values of RTA fatalities and injuries in the UAE during 1995 the study added the direct and indirect costs of RTAs calculated under the HC approach to the adjusted WTP estimates. The results are presented in table (65).

Table (65)
Comprehensive RTA Fatality and Injury Costs in the UAE during 1995
(Value in AED)

Injury Severity	Direct and Indirect RTA Costs	Value of Reduced Quality of Life	Comprehensive RTA Costs
AIS 1	18,733	32,400	51,133
AIS 2	40,658	236,000	276,658
AIS 3	86,076	472,000	558,076
AIS 4	1,623,066	1,766,400	3,329,460
AIS 5	1,565,017	2,355,000	3,920,017
Fatal	1,601,957	5,888,000	7,489,957

These costs represent the comprehensive costs of RTAs in the UAE during 1995. Compared to the monetary costs of RTAs, estimated using the HC approach, the comprehensive costs per AIS categories were an order of magnitude higher than their economic equivalent. The comprehensive cost of AIS-1 is more than twice its economic equivalent; AIS-2 is more than seven times higher, AIS-3 more than six times higher, AIS-4 more than two times higher, AIS-5 more than two times higher and fatalities more four times higher.

Based on the unit cost estimates shown in Table (65), the numbers of RTA fatalities and injuries per AIS and the numbers of PDOs the total comprehensive costs of RTAs in the UAE were calculated and presented in Table (66).

Table (66)
Total Comprehensive Fatality and Injury Costs in the UAE during 1995
(Value in million AEDs)

Injury Severity	Number of Injuries / Crashes	Reduced Quality of Life	Comprehensive Costs of RTAs	Total Comprehensive Costs (in millions)
PDO	80,000	--	--	355
AIS 1	4445	32,400	51,133	227
AIS 2	1751	236,000	276,658	483
AIS 3	2396	472,000	558,076	1,438
AIS 4	720	1,766,400	3,329,460	2,376
AIS 5	339	2,355,000	3,920,017	1,322
Fatal	690	5,888,000	7,489,957	5,106
Total	90,341			11,407

As shown in the Table (66) the total comprehensive cost figure for the UAE during 1995 amounted to AED 11.4 billions (equivalent to US$ 3 billions), which is three times higher than the equivalent economic cost.

9.7 Savings from the Introduction of Safety Seatbelt Legislation in the UAE

The results of the post evaluation showed a reasonable rate of seatbelt compliance in the UAE, following the enforcement of the legislation. The comparative analysis of the pre/post evaluations demonstrated that there has been a significant downward shift of injury severity from 'severe and serious' injuries in the pre-evaluation towards 'minor' injuries in the post-evaluation period (Chi-Square = 77.68, $p<0.0001$) (Fig. 23). A notable reduction in hospital admission rate was also seen in the post evaluation period compared to the pre-evaluation period (Fig. 21) although the result was not significant ($p=0.24$).

The study used the average rates and ratios, calculated for the reduction in injury severity per AIS category in the post-evaluation, to estimate the possible reduction in injuries of higher severity (moderate to critical) if those who sustained injuries during 1995 selected to use safety seatbelts. The calculation yielded the following outcomes when applied to RTA nonfatal injury data of 1995 (Table 67).

Table (67)

Estimates of RTA Injury Outcomes during 1995 if Motorists Used the Seatbelt

AIS Injury codes	Numbers of RTA Outcomes in 1995*	Rates used to estimate % change in distribution of injuries if belts were applied	Estimated Injuries if motorists used seatbelts
No Injury	7730	+6.2% to No injuries	8331
AIS-1	4445	78.9% of all injuries	7646
AIS-2	1751	7.5% of all injuries	727
AIS-3	2396	5.6%of all injuries	543
AIS-4	720	1.9% of all injuries	184
AIS-5	339	0%	0
Deaths	690	the average ratio (3.6)	192
Total	18071		17623**

* Data according to UAE police reports (MoI Annual Report, 1995).
** The difference in the total number is due to the recalculation and rounding.

Based on the distribution shown above (Table 67) the total economic cost of RTA injuries during 1995, using the average unit cost estimates presented in table (58), would have been AED 1.5 billion (Table 68) instead of 3.8 billion as estimated when seatbelt legislation was not in effect (Table 61). That is 62% lesser than the total amount estimated for RTA costs during 1995. Direct RTA costs (including medical care, emergency services, insurance, legal and court administration, workplace costs and property damages amounted to AED 821 million. Indirect RTA costs (workplace household productivity losses) amounted to 650 millions (Table 68).

Table (68)

Summary of Total Costs of RTAs in the UAE during 1995
If Motorists used the Seatbelts

(Using the effective discounting rate equivalent to 4.2%)

(Value in AED)

RTA Cost Components	Minor	Moderate	Serious	Severe	Critical	Fatal	PDO	Total
Direct RTA Costs:								
1- Medical Care	17,708,136	8,579,327	21,237,816	8,392,240	-	1,467,648	-	57,385,167
2- Premature Funeral	-	-	-	-	-	1,158,144	-	1,158,144
3- Emergency Services	16,393,024	1,558,688	1,164,192	394,496	-	854,208	152,190,864	172,555,472
4- Insurance administration	12,264,184	1,166,108	870,972	295,136	-	307,968	130,371,516	145,275,884
5- Legal and court admin.	20,391,882	1,938,909	1,448,181	490,728	-	3,936,000	16,255,800	44,461,500
6- Work place costs	14,902,054	4,250,042	6,349,299	7,441,328	-	7,764,864	8,453,016	49,160,603
7- Property damages	29,620,604	2,816,398	2,103,582	712,816	-	743,808	314,874,846	350,872,054
Subtotal *(Direct Costs)*	**93,571,748**	**11,730,145**	**11,936,226**	**9,334,504**	**-**	**16,232,640**	**622,146,042**	**820,868,824**
Indirect RTA Costs:								
8- Workplace Productivity	27,196,822	7,894,493	11,549,610	241,232,280	-	246,237,312	16,743,474	550,853,991
9- Household Productivity	4,748,166	1,352,947	2,013,987	39,684,384	-	45,105,792	5,852,088	98,757,364
Subtotal *(Indirect Costs)*	**31,944,988**	**9,247,440**	**13,563,597**	**280,916,664**	**-**	**291,343,104**	**22,595,562**	**649,611,355**
Total RTA Costs	**125,516,736**	**20,977,585**	**25,499,823**	**290,251,163**	**-**	**307,575,744**	**644,741,604**	**1,470,480,179**

CHAPTER 10

DISCUSSION

CHAPTER 10

DISCUSSION OF RESULTS

10.1 RTA Epidemiology: Trends of Morbidity and Mortality in the UAE

When the UAE's mortality rates from RTAs were compared with the equivalent rates in other developed and developing countries, RTAs presented a grave public health problem in the UAE. For the rate based on population, only two countries – Kuwait and Portugal - were worse. For the rate based on motor vehicles, for the year 1991, the UAE far exceeded all other countries in the list.

Except for a short period between 1981 and 1982, the rates of RTA fatalities and injuries showed progressive declines despite the increases in the numbers of people and vehicles at risk over the period 1981-1995. The secular trends of the UAE's RTAs, analysed in this study were unusual, illustrating a double paradox. Firstly the rates of RTA per 100,000 population and per 100,000 registered motor vehicles, declined by proportions of 60.5% and 62% respectively during the period 1981-1995. These declines were most probably attributable to improvements in roadway traffic engineering and design, roadway traffic controls and the provision of other safety measures on the roads. Starting from the early 1980s the UAE has enjoyed an excellent roadway network, probably the best in the Middle East, due to the sizeable expenditure on this sector over the 1980s and the 1990s (UAE-ASA: 1975-1997). For instance, the total length of paved highways in UAE reached 3,254 kilometres in 1995, from 700 kilometres only in 1975 (an average annual increase of 19%). Most of the roads in the UAE are now dual carriage roads, properly illuminated at night, well equipped with traffic signs and of a superior design in general. Moreover, starting from the early 1990s many safety interventions were made to curb RTAs including the enforcement of speed limits, by speed radar systems, provision of median barriers, steel guard rails along road edges, traffic safety awareness campaigns, etc. Yet, however, staring from 1985 the risk of injury and death in RTAs in the UAE witnessed gradual and progressive increases; i.e. the severity rates of injury and death per 1000 RTAs more than doubled between 1985-1995. This result evidently revealed that the probability of surviving a roadway traffic accident in the

UAE had actually declined by over 100% just over a 10 year period; or, in other words, the chances of death in a traffic accident in the UAE had more than doubled from 1985 to 1995.

These paradoxical patterns suggest that, whereas various improvements in traffic management have been reducing the numbers and the rates of RTAs - despite the increases in the numbers of people and vehicles at risk - the severity of RTAs, when they did happen, was constantly worsening.

While the precise reason for that remains unclear as yet, due to the limitations of this study, a number of underlying factors might have been contributing to the rising fatality rates in RTAs in the UAE; in particular: the low level of seat-belt usage in the UAE, the change in vehicle types, and the failure in casualty management. Firstly, mandatory seat belt usage was not introduced and became effective in the UAE until 1999. The rates reported in 1995 for constant and frequent seatbelt uses in the UAE were below 11% and 6% respectively (Bener, *et al.*, 1994). Secondly, vehicles on the roads have changed in type: the older heavier models in the UAE which resisted deformation in crashes, have been replaced by smaller, more lightweight and more fuel-efficient models (MoI Annual Reports: 1981-1998). According to official reports, the proportion of heavy and moderate passenger vehicles (8 and 6 cylinder motor vehicles) declined significantly from 38% in 1985 to 23% in 1998, while the number of light vehicles increased by an offsetting proportion (MoI Annual Reports: 1981-1998). Evidence exists in the literature to suggest that the transformation from heavier to lighter vehicular models, following the 1974 and the 1980 oil crisis, contributed largely to the deterioration of road safety standards (Lawrence *et al.*, 1994). It is established that smaller vehicles have higher occupant death rates because of the smaller interior space in which occupants can decelerate (Robertson, 1996). The wheel-base, the difference from the front to rear axle of the vehicle, is the best predictor of differences in fatality rates, due to vehicle size (Robertson, 1996). Another main cause of the situation may have been the increasing difficulty in the management of serious injury following RTAs. In the UAE there is a very low level of first-aid knowledge in the community (Norman, *et al.*, 1998). Until recently indeed there was a general fear of blame being attached to those who attempted to help at an accident scene. While there are well-equipped ambulances in the UAE they are rarely staffed with personnel knowledgeable in casualty handling. It seems reasonable to suppose that as RTAs become increasingly complex, progressively greater skill in casualty handling will be needed to manage the victims of these disasters. Road engineering and hospital services have now reached a high standard in the UAE but it is suggested that there is an important service gap still to be filled in pre-hospital care. Finally, it is suggested that the factors so far discussed are not sufficiently different from other areas to count for the paradoxical finding of this study.

The three categories of RTA causal factors with persistently high percentages (i.e. careless driving, over-speed and personal factors) were most probably attributable to lack of personal competence and/or judgement; but the precise underlying reasons for that result require further investigation. The low values for environmental factors, vehicle condition and roadway conditions most probably were due respectively to the rarity of meteorological hazards such as fog and rain, to the enforcement of annual vehicle inspection and again to the excellent quality of the road network and traffic control. The low percentage of accidents linked with alcohol presumably reflected the cultural disapproval of alcohol. The contribution of drugs cannot yet be defined in the absence of a roadside test. The reason for the increasing incidence of serious injury and fatality was unclear, particularly since the proportion of RTAs attributed to driver behaviour apparently declined, as did excessive speed and alcohol involvement. The declines for these categories might have resulted from improvement in road design and traffic control. The cause of the increased contribution of human factors was difficult to understand. Perhaps this may be due either to a factor in accident causation which has not yet been determined or to increasing difficulty in the management of serious injury following more complex accidents. It is possible, therefore, that, despite the provision of modern equipment and transportation systems for the care of RTA victims, there remains a need to focus on the level of training needed for those personnel responsible for the management of the victims of RTAs.

The analysis of total RTA fatalities and injuries by age group throughout the years 1983 to 1995 revealed that those mostly affected by RTAs injuries and fatalities were individuals in middle age groups (21-30 years) and (31-40 years). A massive proportion of 69% of total motor-vehicle crashes, 57% of total RTAs' deaths and 56% of total RTAs' injuries were sustained by individuals from these two age groups. In addition, 85% of these deaths were among males.

Although these results might not be more than a resemblance to the population pyramid of UAE population, where the middle age class (20-40 years) form more than 55% of the population, still they reflect the losses imposed by RTAs on UAE society in terms of lost years of productivity, due to premature deaths among such young age groups. The age groups above 40 years, which formed 9% of the UAE population, sustained less than 15% of total accidents, 13% of total RTA injuries and 17% of total RTA deaths. Whereas the age group below 14 years, which formed 34% of total UAE population, sustained 1% of total motor-vehicle crashes, 13% of total RTA injuries and 13% of total RTA deaths. These results support the argument that failure in applying restraints on children would mostly increase the probability of injury and death among them in motor-vehicle crashes. Vehicle-to vehicle collisions were the major type of accidents among individuals from the age range (20-40 years) followed by vehicles-turnovers and vehicle-pedestrian crashes.

10.2 Forecasting Future Trends of RTA Fatalities in the UAE

To estimate future forecasts of RTA fatalities in the UAE the study attempted to fit the UAE data during 1980-1998 using Smeed's model. The model has long been used as predictive tool for analysing future trends of mortality from RTAs, using the numbers of population and motor vehicles. Unfortunately, the model gave a prediction error exceeding 30%.

In view of that a multiple regression model was developed for the UAE. In addition to the factors of population and motor vehicles, used in Smeed's formula, the model incorporated other factors that are believed to optimise the final equation, and therefore, to produce better fit and prediction power. The factors of motor vehicles' kilometres driven, excessive speed, drivers' age when killed in RTAs, UAE annual disposable income and GDP were added to the equation using the stepwise method with backward iteration. ANOVA was used to test the overall significance of the model and the t-test was used to test the significance of individual parameters. Better results were obtained when the model was applied to the UAE data during the period 1980-1998. The model gave an average percentage error <. 05.

The analysis revealed that drivers aged 18-40 years have the highest impact on RTA fatalities in the UAE. This reflects an underlying problem that is most likely associated with drivers' behaviours of individuals from this age group. It is likely that speedy driving, lack of adequate training and failure to apply safety seatbelts by youngsters and new drivers are among those factors, as has been suggested elsewhere in this study and by many authors before.

The analysis also revealed that the coefficient for the population had a significant positive sign (p=0.006), a result that confirms the fact that as the population increases RTA fatalities also tend to increase. The gross domestic product (GDP) factor appeared to have a significant inverse relation (p=0.005) with RTA fatalities, indicating that with higher GDP the higher the expenditure on roadway infrastructure, a factor that is likely to cause roadway safety to improve as well. The resulting equation indicates that with a 10% increase in GDP an overall RTA fatality improvement of 3.1% could be expected. This is not to jeopardise the fact that such an improvement could be offset by other contributing factors such as negligence, speedy driving, or avoidance of seatbelt use. Mileage driven also proved to have an inverse relation with RTA fatalities, i.e. the higher mileage driven the lesser RTA fatalities and vice versa. This might partially be reflecting the impact of transportation density on calming roadway traffic and, therefore, positively affecting severity of car crashes, i.e. reducing RTA mortality.

The model proved to fit the UAE data very well ($p<.001$, R^2=0.995). Thus, apart from the mileage driven, the future trends of RTA mortality and morbidity as well are most likely to rely upon the existence or absence of improvements in the areas whish have been pointed out. In other words, to control RTA mortality, the most severe outcome of RTAs and, therefore, to improve roadway safety in the UAE, the drivers aged 18-40 should be targeted for safety campaigns and interventions.

10.3 Evaluation of Effectiveness of Seatbelt Legislation in the UAE

The comparative analysis of the pre/post evaluations revealed important information on the effectiveness of seatbelt legislation in the UAE. The sex distribution of RTA casualties remained the same in the pre and post evaluations (84% males to 16% females vs. 82% to 18%) respectively. Also, the proportionate distribution of casualties according to nationality did not differ in the pre and post evaluations (Fig.17). Asians continued to form the highest involvement proportion in RTAs in both evaluations (43% vs. 45%), reflecting their high ratio in the country's population (50%). UAE citizens formed the second highest involvement proportion in both evaluations (29% vs. 31%) despite the fact that they represent around 20% of the population. Other Arabs formed (28% vs. 24%) in the two evaluations. The high rate of involvement of UAE citizens is alarming and is suggesting that safety campaigns should be targeted upon them. The contribution of the young age groups (19-24 and 25-34 years) in RTAs increased from 44% in the pre-evaluation to 59% in the post evaluation (chi-square 4.50, p=0.03), while the contribution of the age group 45> years, declined from 14% in the pre-evaluation to 8% only in the post evaluation (the result is not significant). These results suggest a declining severity trend in RTA injury among old age groups and an increasing trend in the young age groups; a pattern which might be reflecting non compliance with seatbelts among the latter groups, over speeding or some other factor that is worthy investigating.

The post evaluation shows that 59% of casualties involved in crashes reported the use of a seatbelt when the crash occurred (Fig. 24). Although this self-reported evidence might overestimate the actual rate of seatbelt compliance among front seat passengers in the UAE, taking in mind the fines imposed on violations, yet it suggests a notable improvement as opposed to the rates reported by Bener, *et al.* (1995), which estimated these rates to not exceed 11% for frequent users and 6% for non-frequent users (Bener, *et al.*, 1995). The analysis of the association between age group and seatbelt use in the post evaluation further confirm the preceding results. For the age group (0-18 years) the analysis revealed that 42% used seatbelts compared to 58% (p=00.01). For the age group (19-34 years) 53% were found using seatbelts compared to 47% non-users (Chi-Square =9.97, p=0.01). However, in the age groups (35-44 and 45>) the pattern reversed and seatbelt users increased to 80% and 86% respectively

(p=0.01). The analysis of the association between seating position and seátbelt-use revealed that 86% of drivers and 87% of front seat passengers were found using seatbelts compared to 14% and 13% non users respectively (p<0.001). On the other hand 89% of back seat passengers were found not using seatbelts when the crash occurred, compared to 11% users only (p<0.001).

Indeed a clear and more reliable estimate could have come from an observational beside-the-road setting. Nevertheless, an important and more objective clue to this improvement is suggested by the reduction in injury severity demonstrated by the results of the post-evaluation, as will shortly be explained. However, it should be stated that similar rates of compliance, following enforcement of seatbelt legislation, were seen elsewhere. In the US Marburger and Friedel (1987) estimated the rate of compliance to be within the range of 60-90 percent, while Hauswald (1997) estimated the actual rate among drivers to be within 40% only. NHATSA in the CODES report (1996) adjusted police estimates for compliance in various RTA injuries to range between 20% (in any injury) to 60% (in confirmed deaths).

To assess the overall benefit of the seatbelt legislation in reducing RTA injury severity in the UAE, the study compared the proportion of the group of casualties who sustained 'moderate to severe or critical injury' with the group that sustained 'minor or no injury' in the pre and post evaluations. The analysis revealed a proportion of 15% in the post evaluation compared to 54% in the pre-evaluation (p<0.0001). In other words, the relative risk of sustaining moderate to severe or critical injury in RTAs following seatbelt legislation compared to the pre-evaluation period declined 3.6 times. The individual comparison per AIS injury categories revealed a similar significant declining trend (p<0.0001). Critical injuries during the post evaluation declined from 2.4% to zero. Severe injuries declined from 8.3% to 2% only (p<0.0001). Serious injuries declined from 24.4% to 5.2% (p<0.0001). Moderate injuries from 18.2% to 7.5% (p<0.0001). More important, minor injuries increased from 42% during the pre-evaluation to 79% (p<0.0001) in the post evaluation, a pattern which reflects a downward trend of severity in RTA injuries in the UAE following the enforcement of seatbelt legislation in 1999 (Fig.23).

The analysis of hospital admissions in the pre and post evaluations further confirmed the preceding trends. The analysis of the post evaluation data showed that 65% of casualties received at hospital were discharged from the Emergency Room (ER) compared to 57% only in the pre-evaluation period (*p*=n.s.). Likewise, hospital admissions declined to 35% in the post evaluation compared to 42% in the pre-evaluation (*p*=n.s.). Although the results were of border significance (*p*=0.24) for admissions in pre-evaluation compared to the post-evaluation period, still reflect a reduction in the proportion of admissions to hospital for 'moderate to critical injuries'. This is again confirming the reduction of RTA injury severity following the application of seatbelt legislation.

The comparison of the number of hospital bed days of those admitted to hospital in the pre and post evaluations has some how resembled the pattern described so far. The proportion of those who spent less than a week increased from 63% in the pre-evaluation to 69% in the post evaluation (*p*=n.s.) (Fig. 21). However, the proportion of those who spent 1-2 weeks increased significantly from 10% to 18% (*p*=0.004) (Fig. 21). Interestingly, the proportion of those who spent 2-3 weeks declined from 10% to 4% only following enforcement of seatbelt legislation. The proportion of those who spent 3-4 weeks declined from 8.4% to 4.3% (*p*=n.s.) and the proportion of those who spent more than 4 weeks declined from 9.6% to 4% (*p*=n.s.). Although statistically insignificant, the results demonstrate a clear improvement in the proportions of long term hospital admissions following the enforcement of seatbelt legislation.

To assess the cost effectiveness of seatbelts in the UAE the study compared the costs of RTAs during 1995, which represent RTA costs before seatbelt legislation, with costs hypothesised for the same year on the basis of injury severity ratios following the enforcement of seatbelts in 2000. The analysis yielded a reduction in total RTA costs amounting to AED 2.4 billion (62% lesser than the pre-evaluation estimate). In other words, the enforcement of seatbelts in the UAE during 1995 could have reduced the direct and indirect costs of RTA injuries by 62% and saved the country AED 2.4 billion. These overall savings are found very close to those estimated by the CODES report for the US where it was suggested that seatbelts could have reduced total RTA costs by 55%. Miller (1998) produced a reduction estimate for the US amounting to 42% of the total crash cost.

The comparison of the individual elements of RTA costs for the pre and post evaluations showed that medical costs declined from 196 million in the pre-evaluation to AED 57 million in the post evaluation (71% decline), a proportion that is almost identical to the estimate produced by Marine *et al.* (1994) for the cost effectiveness of seatbelts in Colorado (76% decline for medical costs and 72% for hospitalisation). Workplace costs declined from AED 126 million in the pre-evaluation to AED 49 million in the post evaluation (61% decline). This reflects the shift in injury severity and disability towards lesser severe injuries and, therefore, lesser incapacitation which in turn produced a sizeable saving in workplace costs. The indirect cost elements of RTAs - household and workplace productivity losses - are the most heavily affected elements by the reduction in RTA injury severity, following enforcement of seatbelt legislation. Together, their magnitude declined by 76%, from AED 2.8 billion to AED 650 million only.

In conclusion the analysis of the pre and post evaluations demonstrated that the enforcement of seatbelts in the UAE was effective in reducing morbidity and mortality from RTAs. The results also demonstrate that the legislation caused a downward shift in the RTA injury severity, RTA hospital admissions and hospital stay. The ratios of the effectiveness of seatbelts in the UAE were found close or similar to those produced elsewhere.

The analysis also revealed a sizeable reduction (62%) in the total costs of RTAs in the UAE if those unbelted when the crash occurred elected to use the seatbelt during 1995. The results showed a 72% decline in medical costs, 61% decline in workplace costs, and 76% decline in household and workplace productivity losses.

10.4 The Economic Impact of RTAs in the UAE during 1995

Little has been done before to evaluate the economic impact of RTAs in the UAE. The same applies to the neighbouring Arabian Gulf countries, which share similar environments and face almost identical roadway traffic problems. However, a few estimates of a very arbitrary nature of the RTA problem have been made in the region. For example, in the UAE, a study by Abdalla and Wadell, (1999) estimated the unit cost per roadway crash to amount AED 5,400 during 1991. The estimate, based on insurance data alone, was made for RTA material damages only. In Kuwait, Jadaan (1986) estimated RTA losses to amount to 2 percent of the annual GDP. In Jordan a study estimated RTA costs to amount to JD 63 million in 1986, accounting for 2-3% of the annual GDP (Jadaan, 1986). Most of these estimates suffered data limitations and were largely based on guessing rather than reliable data. Therefore, they are not reliable enough to use for assessing external validity or to draw meaningful comparisons. For these reasons, we decided to look into the international literature for comparison.

10.4.1 Total Costs of RTAs in the UAE during 1995

The study used primarily the HC approach to estimate the economic costs of RTAs in the UAE during 1995. These costs included the direct and indirect human and material damages associated with RTAs in the UAE during that year. Direct cost components of RTA fatalities and injuries were property damage, the entire range of medical and ancillary care costs, insurance administration costs, police and court administration costs and workplace costs. Indirect cost components included productivity losses in the workplace due to temporary or permanent disability and decreases in home production due to RTA fatalities and disabilities. In addition the costs of pain, grief and suffering (PGS) or lost quality of life, which occur to individuals, following RTA injuries, were included. The study attempted to measure these non-monetary intangible losses by building upon estimates derived worldwide after adjusting them for the UAE. However, other indirect costs such as traffic delay losses, payments to casualties' dependants from public assistance, private insurance and other sources were not included due to time and resource limitations.

10.4.2 Total YPLL and DALYs due to RTA Fatalities and Injuries

The study revealed that total years of potential life lost (YPLL) due to RTA fatalities in the UAE during 1995 – the product of average YPLL times the number of people killed in RTAs – was 23,180. The average time loss (DALYs) per injury per AIS category ranged from 0.05 for minor injuries (AIS-1) to 0.3 for serious injuries (AIS-3), while severe and critical injuries (AIS-4 and 5) were considered permanent disabling conditions. Total DALYs due to nonfatal RTA injuries during 1995 were 33,800.The analysis showed that severe injuries cause the highest time loss per injury, totalling 23,000 DALYs per year and accounting for over 40% of the total loss. Critical injuries were found causing the third highest time loss per injury, totalling 9,612 DALYs and accounting for 17% of the total loss. Serious, moderate and minor injuries caused the least, causing together a loss of 1208 DALYs per year and accounting for less than 3% of the total loss.

10.4.3 The Monetary Costs of RTA Fatalities and Injuries

The total monetary cost picture of RTAs, which took place in the UAE during 1995, amounted to AED 3.8 billion, equivalent to US$ 1 billion (Table 60). This amount represents the human and material losses of 690 RTA fatalities, 9,691 nonfatal RTA injuries and 82,000 damaged vehicles that resulted from RTAs in the UAE during 1995. For the RTA fatalities during 1995 the costs exceeded AED 1.1 billion. For the RTA (nonfatal) injuries and property damages the cost exceeded AED 2.7 billion. The direct monetary costs of RTA fatalities amounted to AED 60 millions while the indirect costs of those fatalities exceeded AED I billion. The direct costs of RTA injuries and property damage during 1995 amounted to AED 1 billion and the indirect costs of those injuries amounted to AED 1.7 billion. Of the total cost of RTAs, severe injuries were found the most costly injury category, amounting to AED 1.2 billion and accounting for 31% of the total cost (Table 60). The increasing cost of this injury category was due to two reasons: the presence of a large cohort of severe injuries among young age groups, especially UAE teenagers. Fatal RTA injuries were the second most costly injury category in the UAE, amounting to AED 1.1 billion and accounting for 29% of the total loss (Table 60). Property Damage Only crashes (PDOs) (the non-injury crashes) were the third most costly component of RTA costs, amounting to AED 651 million and accounting for 17% of the total loss. To estimate the cost of PDOs in the UAE, the study added to the cost of material damages, unit cost estimates for workplace and household productivity losses in addition to costs of emergency services. The resulting figure was considered to be the PDO crash costs.

Critical injuries were the fourth most costly category, amounting to 533 millions and accounting for 14% of the total cost (Table 60).

Out of total RTA costs in the UAE, workplace productivity loss (AED 2.4 billion) accounted for 61.6% of the total cost. Household productivity losses (AED 407 millions) accounted for 10.6% of the total cost. Thus, the two cost components of productivity loss alone amount to AED 2.8 billion, which represent 72% of the total cost. This high percentage reflects the emphasis the HC approach places on productivity-potentials forgone by the society due to premature death and/or permanent incapacitation from RTAs. Compared to other studies using the HC approach, the magnitude of our estimate for this component was found to be higher than in some studies but similar to estimates drawn in other, often earlier studies. For example, Blincoe and Faigin (1992), in a study estimating RTA costs in the US during 1990, found the two components representing 37% of the total cost (Blincoe and Faigin, 1992). In an update to the US costs for 1994, the magnitude of these two components further decreased to 35% (Blincoe and Faigin, 1994). The apparent reason for the lower magnitude of these comparative estimates was the presence of high incidence of minor PDO crashes in the US data, which allowed that element to rank first instead of productivity losses. Another US based study for the region of Kentucky, Goldstein, *et al.* (1994), using the NHTSA's Crash Cost programme, generated an estimate of productivity losses amounting to 80% of the total cost (Goldstein, *et al.* 1994). Earlier, Miller et al. (1989) estimated the cost of productivity losses in the US during 1989 to constitute 90% of the total cost. Thus, it is possible that improvement in data compilation, through integrating additional data sources of RTA costs in the UAE, particularly data in minor PDO crashes, workplace and household productivity losses could shrink down to constitute less than 50% of total RTA costs.

Following in third place behind workplace and household productivity losses were property damage costs which amounted to AED 355 millions and accounted for 9.3% of the total cost of RTAs in the UAE during 1995. In the absence of detailed data, the study estimated the average cost of this component by aggregating the total cost of property damages due to RTAs during 1995 – based on insurance sources - and divided that by the total number of casualties during that year. The resulting ratio represents the unit cost of property damage per RTA casualty. That estimate was used as the average unit cost of property damage per casualty for all RTA injury categories. However, the estimates drawn for property damages did not include unreported RTAs and also RTA damages that did not qualify for the threshold amount deductible in comprehensive insurance policies. Evidence exists to suggest that those who chose not to report to their insurers involved, on average, in one-tenth of the average property damage in reported crashes (Miller, 1994). This could also be the case in the UAE, though no empirical evidence exist to support it. Also, it is likely that many minor accidents, especially single vehicle accidents, do not claim for insurance in the UAE and as such their costs will remain beyond the reach of this study. Furthermore, it is well known in the UAE that most RTA damages, even when reported, are not adequately covered and compensated for by insurance. It could thus be said that the present estimates, drawn on the basis of insurance data alone, could be far less than the actual cost of this component. However, up to date, apart from insurance data, there is no other data source for these costs in the UAE. It is clear that the development and use of a database compiling the actual property damages resulting from RTAs, based on neutral assessment, could well improve the accuracy of the estimates. For all of these reasons the magnitude of estimates produced by the study could be less than the comparative estimates drawn in other countries. For example, in the US, NHATSA estimated the cost of property damage of all crashes (fatal, injury and PDO) to account for 35% of all RTA costs during 1994, the magnitude of which is higher than any other cost category (Blincoe and Faigin, 1994). As mentioned before, the clear reason for this high estimation was the inclusion of high estimates for unreported motor vehicle crashes in the US. However, the earlier US estimates, which were most likely suffering similar shortage of data like the UAE, found the magnitude of property damage in a proportion of total RTA costs as low as 14% (Miller et al. 1989).

The medical costs of nonfatal RTA injuries constituted the fourth highest cost component of RTA costs in the UAE during 1995, amounting to AED 223 millions and accounting for 5.1% of the total cost. Compared to other injury categories, the cost of serious injuries ranked the highest, amounting to AED 106 millions and accounting for 50% of total medical cost. Severe injuries ranked the second highest amounting to 48 millions and accounting for 21% of the total medical cost. Critical injuries ranked third, amounting to 30 million and accounting for 13%. Moderate and minor injuries together amounted to 39 million and accounted for 16%. Fatal RTAs accounted for 5 million and accounted for less than 3% of total medical cost.

It should be noted that the medical cost estimates in this study are of a preliminary nature and, therefore, should be taken with discretion for a number of reasons. Firstly, the estimated outcomes and costs of RTA injuries during 1995 might not reflect the actual burden because the sample from which these estimates were made was taken in the year 1998. There is evidence that RTA injury severity in the UAE declined over the second half of the 1990s, following the enforcement of seat belt legislation in the UAE and also due to improvements in roadway engineering and traffic control. In addition, the study used the official rates and charges of the Ministry of Health as a basis to calculate the medical costs of RTAs. These rates and charges are known to be lower than actual costs due to subsidization, and as such may not reflect the actual burden of medical care. Thirdly, the AIS codes which are used in the study, whilst providing a suitable and convenient method to understand morbidity from RTA injuries, they remain insufficient to describe the far reaching outcomes of RTA injury. Technically, the AIS codes are meant to measure the immediate threat to life posed by injuries, not the far-reaching effects of those injuries, which may differ in the long run (Miller, 1989; Blincoe and Faigin, 1994). Additionally, in practice, the AIS codes are usually assigned during the early stages of injury treatment. In many instances, especially for minor and moderate injuries, outcomes may not accurately be depicted by these initial AIS codes. For example, injuries assigned low AIS codes, such as lower extremity fractures might result in unpredictable serious long-term outcomes such as neurological damage. Such effects are most likely to be overlooked if the cost analysis of outcomes is solely based on the AIS classification. Thus, in the absence of a database linking final injury outcomes with AIS codes the true burden of RTA injuries will remain doubtful.

For all of the above-mentioned reasons the estimate produced for medical costs is likely to be lower than the actual burden. A proportional cost of 5.1% out of the total cost is evidently far below the comparative rates worldwide. For instance, in the US, Blincoe and Faigin (1994), using the HC approach, estimated the medical costs of RTAs to constitute 11.3 percent of the total and 22 percent of the cost of nonfatal RTA injuries during 1994. An earlier evaluation by Blincoe and Faigin (1990) showed medical costs represented 10% of the total cost of RTAs. The apparent reasons for the difference between this estimate and ours is the absence of detailed data on RTA outcomes in the UAE in general and data on long-term treatment costs of RTA victims in the UAE in particular, especially for casualties suffering from moderate to severe RTA injuries (AIS 3 to 5) who require long term and complicated procedures to restore their pre-crash physical and mental well-being. It has already been demonstrated that 10% of hospitalised patients are frequently transferred to specialised trauma centres for further treatment. In the absence of a follow up system for such patients in the UAE their further treatment costs remained out of our reach. It is established that the medical costs of these latter groups are extremely high compared to those of lower injury severity (AIS 0 to 2). Miller (1989), estimated the medical cost resulting from AIS 4 and 5 to constitute 40 to 45 percent of their total unit costs. Goldstein et al. (1994) estimated the medical costs of critical injuries to account for 45 percent of their total unit costs. Yet, in the UAE and due to the non-existence of data reporting final injury outcome and total hospital cost data, the costs of these severe injury categories were missed. To improve the accuracy of evaluation of medical costs in the UAE it is imperative to introduce a database for RTA injuries organised by injury outcomes. Such development would integrate short and long-term outcomes of RTA injury together with their final medical costs, thus, paving the way for detailed and accurate estimation of these costs.

The fifth highest RTA cost in the UAE during 1995 was emergency services cost (police, ambulance and civil defence fire costs). The three components together amounted to AED 191 millions and accounted for 4.6% of the total cost. A microanalysis was carried out to estimate the average costs of ambulance care for RTA victims, based on detailed data obtained from the Ambulance Services department of Dubai Police. Statistical interpolation was used to estimate police and fire services cost, based on cross sectional data obtained from Al-Ain Traffic Police Department and the Civil Defence. These average estimates were multiplied by the number of RTA casualties during 1995 to generate the total cost of emergency services from RTAs in the UAE during 1995. Compared to the US estimates the UAE estimate was found higher by three fold (Blincoe and Faigin, 1994). The reason could rest in the detailed nature of our analysis for this component and the better availability of data compared to other RTA cost components.

Insurance administration, the difference between premiums paid to insurance companies for motor vehicle insurance and claims paid out by these companies to insurers, ranked sixth among RTA cost components. It amounted to AED 147 millions and accounted for 4% of the total RTA cost in the UAE during 1995. The magnitude of this component is reasonable compared to similar studies carried elsewhere. For example, in the US, Blincoe and Faigin (1994) estimated the contribution of insurance costs to total RTA costs in the US during 1994 at around 7 percent. As stated before the difference is likely to come from the increased number of PDO crashes in the US compared to the UAE.

Workplace costs ranked seventh, amounting to 126 million and accounting for 3.3 percent of total costs. This is meant to measure the indirect effect of RTA injury in the production process - apart from direct productivity loss - which has been analysed separately. It is clear that RTA fatality, injury and disability would have an indirect effect in terms of delays in production apart from the direct productivity losses of workers. Additionally, the costs of replacement for the permanently disabled victims must be included. To estimate this component, the study first estimated parameters for disability resulting from RTA injuries per AIS category. To achieve that, the study analysed a sample of RTA injuries as explained earlier. The resulting parameters were applied to the RTA injury data of 1995. The production downtime was measured by multiplying these estimates, per AIS category, by the hourly labour payment in the UAE. Added to that the study estimated the costs of replacement of permanently disabled workers and the average time taken to replace labourers by analysing a sample obtained from employment agents in the UAE. However, the estimates produced could be far less than the actual burden due to the fact that our estimates were based on average hourly wages rather than actual productivity that is lost to industry, which might far exceed labour wage payments.

The remaining two elements of RTA costs, i. e. legal costs and premature funeral costs were found of little or minor importance, collectively representing less than 2 percent.

The analysis of unit costs of RTAs revealed that the lifetime average unit cost per RTA fatality in the UAE amounted to AED 1.6 million during 1995, of which 95 percent was due to workplace and household productivity losses, again reflecting the emphasis the HC approach places on forgone productivity. This amount is 48 percent less than the equivalent US estimate for 1994 (US$ 830,000). The difference is most likely attributable to income differentials between the US and the UAE.

The average unit costs of severe and critical injuries (AIS 4 and 5) were found analogous to that of RTA fatalities; each amounting to AED 1.6 million, of which 90 percent was attributable to workplace and household productivity losses and 5 percent to medical costs. Other studies that used the HC approach also found that the magnitude of unit costs of these two injury categories was as high as that of RTA fatalities. Blincoe and Faigin, estimated the unit cost of severe injury to amount US$ 706,000; which represents 85 percent of RTA fatality cost during 1994. Miller (1993) estimated the monetary cost of critical injury (MAIS 5) to amount to 80% of the cost of RTA fatality (MAIS 6) ($ 510,000 vs. $641,000). The difference in magnitude in Miller's estimate for the unit cost of MAIS-5 injuries is likely to reflect the differential in medical costs between the UAE and the US rather than differentials in productivity estimates. In addition, the lower estimate for the UAE, is likely to reflect the deficiency in the UAE data, especially for higher AIS categories, due to the absence of a follow-up system that trace patients transferred for specialised care. Goldstein *et al.* (1994) estimated critical injury (MAIS 5) to amount to 88 percent of the cost of RTA fatality (MAIS 6) in Kentucky during 1994, which is much closer to our estimate for the UAE.

The average unit cost of serious and moderate RTA injuries (AIS 3 and AIS 4) amounted to AED 86,000 and AED 41,000 respectively. Of that amount medical costs constituted 45 percent and 29 percent respectively while workplace and household productivity losses constituted 29 percent only for both injury categories. The increased proportion of medical costs for the two categories is reflecting the relative importance of medical and rehabilitation expenses *vis-à-vis* productivity losses for lesser severe RTA injuries. The unit cost of minor injury (AIS-1) amounted to AED 19,000; of which 32 percent was attributable to property damage. The PDO unit cost amounted to AED 8,000, of which 72% was attributable to property damage, 22% to police administration and emergency services and 6% to other RTA cost components. As already noted by other authors, property damage has an inverse relation with injury severity, implying that the lesser the injury severity the higher the impact of property damage cost.

10.4.4 **Sensitivity Analysis**

Recognising the effect of uncertainty in economic evaluations in general, and RTA analysis in particular, the study identified three major cost components as candidates for sensitivity analysis: workplace productivity, household productivity and medical costs. These components are known to have sizeable impacts on RTA cost analysis. Noting the impact of the discounting rate in the calculation of the present value of these components, the study estimated the social rate of time preference (SRTP) to equal the mean interest rate in the UAE over the last 10 years, using time series analysis (Appendix 8). To compute the expected, the optimistic and the pessimistic workplace and household productivity losses the study used a plausible range of the mean interest rate in the UAE ±2SD. To achieve that the study used consistent combinations holding the YPLL and annual forgone earnings constant while varying the discount rate for the three possible scenarios (X)±2SD. Accordingly, the study produced three estimates for workplace and household productivity losses per AIS category per individual casualty. To calculate optimistic and pessimistic estimates for medical costs the study used the lower bound and the upper bound of the mean medical cost per each AIS category. Accordingly, the study produced three consistent estimates for RTA costs in the UAE during 1995; an optimistic total cost of AED 3.1 billion (Table 63), an expected total cost of AED 3.8 billion (Table 61) and a pessimistic total cost of AED 4 billion (Table 62). In other words, the total costs of RTAs in the UAE during 1995 could have been in the range of AED 3 to 4 billions, which represents 2-3% of GDP in the UAE during 1995 (AED 141 billions). The resulting magnitude was found similar to estimates produced in other countries like Jordan (2-3%) of GDP for 1986, Kuwait (2%) of GDP for 1988 and the US (2.2%) of its annual GDP in 1994.

10.4.5 **Rational Investment Levels of RTA Prevention in the UAE**

The economic costs presented so far represent the tangible direct and indirect losses to individual victims and to the society from RTAs. As noted before, these estimates are legitimate to use for estimating savings from reducing a given number of injuries, fatalities or crashes when appraising RTA safety measures and also to estimate the direct economic impact to the country's resources, e.g. health care resources, emergency services, etc. However, other intangible losses, such as pain grief and suffering remain beyond these monetary estimates. Collectively, the two cost categories are known in the literature as "rational safety investment levels" (Miller, 1989), "willingness to pay values (WTP)" (Jones-Lee, 1982) and "comprehensive RTA costs" (Miller, 1993). As noted before, these losses are essential to measure if the welfare benefits from reducing injury were to be understood and considered in policy analysis. In other words, it is important to measure the comprehensive costs of RTAs in order to weigh the quantitative benefits (i.e. reducing numbers of injuries and fatalities) and the qualitative welfare benefits (i.e. alleviating pain and suffering) from measures aiming to reduce RTA injuries. As stated by Miller (1993) Faigin (1994) and others, without that, and if the policy measures were based purely on economic terms the most tragic, and probably the most costly aspects of RTA outcomes will be overlooked.

To determine the monetary value of life in the UAE our study adjusted Miller's figure of 1994 ($ 2.2 million per fatal injury) for UAE. To achieve that the study used the CPI (All Items) to upgrade the US figure of 1993 to the UAE rates of 1995. The calculation yielded US$ 2,290,197.80 per fatality in the UAE. To account for income differentials between the UAE and the US the study used a special index, calculated by dividing the per capita income in the UAE by that of the US over the 1990s. The resulting average ratio was used to account for income differential between the US and the UAE. Time series analysis yielded a ratio of 0.60 (implying a 40% differential). Applying that ratio to Miller's estimate the study yielded a monetary value equivalent to AED 5.9 million in the UAE during 1995 (equivalent to $1.6 million).

The comprehensive costs of RTAs in the UAE during 1995 are much higher than their economic equivalent. For example, the comprehensive costs of AIS-1 injury category is triple its economic cost. The comprehensive cost of AIS-4 is twice its economic cost. The comprehensive cost of fatal injury is 4 times higher than its economic cost. That means it is reasonable and rational to invest up to AED 7.4 million to prevent a fatality, roughly 4 times the cost of such event to the society. The additional cost is the cost of pain, grief, suffering and lost quality of life for the individual and the members of his/her family, which are routinely neglected by the HC approach. On similar grounds, investing up to AED 3.9 million is feasible to prevent one critical RTA injury. It is equally rational to invest AED 3.3 million to prevent one severe injury in the UAE, an expenditure that is twice as high as its estimated economic cost. The rational investment levels for preventing one serious RTA injury is AED 0.6 million, and that for preventing moderate and minor injuries are AED 277,000 and AED 51,000 respectively. Overall, investing up to AED 65,000 to prevent one nonfatal RTA injury is found rational in the UAE (Table 66). Those estimates were found sound compared to estimates made elsewhere, and, thus, are recommended to be used in resource allocation and benefit cost analysis of roadway traffic safety projects in the UAE.

10.4.6 **Savings from the Enforcement of Safety Seatbelt Legislation in the UAE**

To assess the cost effectiveness of seatbelts in the UAE the study compared the costs of RTAs during 1995, which represent RTA costs before seatbelt legislation, with costs hypothesised for the same year on the basis of injury severity ratios following the enforcement of seatbelts in 2000. The analysis yielded a reduction in total RTA costs amounting to AED 2.4 billion (62% lesser than the pre-evaluation estimate). In other words, the enforcement of seatbelts in the UAE during 1995 could have reduced the direct and indirect costs of RTA injuries by 62% and saved the country AED 2.4 billion. These overall savings are found very close to those estimated by the CODES report for the US where it was suggested that seatbelts could have reduced total RTA costs by 55%. Miller (1998) produced a reduction estimate for the US amounting to 42% of the total crash cost.

CHAPTER 11

CONCLUSIONS AND RECOMMENDATIONS

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11.1 Conclusions

1. Despite a huge investment in traffic infrastructure RTAs remain a major problem for the Health of the Community in the United Arab Emirates.

2. The decline in the rates of RTAs per population and motor vehicles in the decade 1985-1995 has been accompanied by a persistent increase in the severity of injury and the rate of death per RTA following such incidents.

3. Drivers aged between 18 and 40 years in general, and the UAE locals at that particular age interval were found responsible for the highest rates of RTA fatalities in the UAE.

4. As the UAE population increases RTA fatalities also increase, but the GDP has an inverse impact; as it increases roadway traffic safety improves and RTA fatality rates per population decrease.

5. The total monetary cost of RTAs, which took place in the UAE during 1995 was AED 3.8 billion (an equivalent of US$ 1 billion).

6. Nonfatal RTA injuries were responsible for the highest monetary cost (71% of the total costs) while RTA fatalities came only second in terms of costs at 29% of the total cost.

7. Property damage ranked third in terms of costs, medical costs ranked fourth while the costs of emergency services came fifth. Insurance administration came sixth, workplace costs seventh while legal costs and premature funeral costs were eighth and ninth and were of minor importance only at 2% of the total cost.

8. Insurance companies in the UAE do not adequately compensate for most RTA property damages and so the actual damage could far exceed the cost shown for this component. This could account for the lower cost of this component compared to data from other countries.

9. The medical costs of RTA injuries constituted 5% of the total cost of RTAs and serious injuries were the most costly category at 47% of the total medical cost. It is likely that the medical costs are underestimated in the absence of detailed data on RTA outcomes in general and long-term treatment costs in particular in the UAE. The proportion of the cost of medical care appears far less than comparative estimates reported for other countries.

10. Three of the main cost components of RTAs were subjected to sensitivity analysis and there were three estimates for total RTA costs for 1995: an optimistic cost of AED 3.1 billion, an expected cost of AED 3.8 billion and a pessimistic cost of AED 4 billion. Thus, the direct and indirect cost of RTAs for 1995 could have been between AED 3 to 4 billions (≈ US$ 1 billion), which represents 2-3% of the GPD in the UAE during 1995 (AED 141 billion / US$ 38.3 billions).

11. The costs presented so far represent the economic impact in material and health terms but take no account of intangible factors such as pain, grief and suffering. To take this into account, use was made of Miller's cost figure of 1993 (US$ 2.2 million per fatal injury) for the UAE, after adjustment. The calculation yielded a cost estimate of AED 6 million per fatal injury in the UAE for 1995.

12. Based on that the estimated comprehensive unit costs of RTAs in the UAE ranged from AED 50,000 per minor RTA injury to AED 7.5 million per fatality during 1995. The total comprehensive cost of RTAs during 1995 amounted to AED 11.4 billion (an equivalent of US$ 4 billion).

13. The introduction of seatbelt legislation in the UAE reduced morbidity and mortality on the roads. It was also responsible for reducing the severity of injury, the admission rate to hospital and the duration of hospital stay.

14. Had seatbelts been worn in every RTA in 1995 there would have been a 62% reduction in the cost of RTAs. This would have resulted in a 71% reduction in medical costs, a 61% reduction in employer workplace costs and a 76% reduction in household and workplace productivity losses.

11.2 Recommendations

1. To improve the accuracy of the evaluation of medical costs as well as facilitating the epidemiological study and control of RTAs it is essential to introduce a computerised surveillance system for RTA injuries in the UAE. The system should integrate police and hospital data to facilitate the identification of the risk factors that cause RTA injuries. RTA injuries should be categorised by final outcomes, integrating short and long-term outcomes with their final medical costs.

2. There is a need for a more precise elucidation of the causes of RTAs and the determination of the effectiveness of traffic safety measures introduced over the past years.

3. More active enforcement of seat belt legislation, more active control of speeding and the introduction of improvements in the care of victims at the roadside and during transportation to hospitals would most likely reduce RTA injuries and fatalities in the UAE.

4. To improve roadway safety in the UAE the establishment of a strategic plan, a multiple partnership or a forum is essential to coordinate the expertise and efforts of individuals and agencies concerned with the research, training and service provision aiming to control RTAs in the UAE.

5. The WHO model of Safe Communities which aims to prevent and control RTA injuries and which has been implemented and tested by several WHO collaborating centres in various countries in the world could provide a fruitful approach to prompt all individuals in the UAE community into joint action aiming to control and reduce RTA injuries.

6. Based on the findings of this study it would seem reasonable to invest up to AED 7.4 million to prevent a fatality, AED 3.9 million to prevent one critical injury and so on down to AED 51,000 to prevent a minor injury. These estimates compare closely to estimates made elsewhere and are thus recommended for use in resource allocation and cost-benefit cost analyses of roadway safety projects in the UAE.

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APPENDICES

APPENDIX (1)

Research Ethics Approval and Covering Letter

RECEIVED
20 JUN 1999

UAE UNIVERSITY
FACULTY OF MEDICINE AND HEALTH SCIENCES

Research Ethics Committee

MEMORANDUM

TO:	Prof. O. Lloyd, Community Medicine
FROM:	Dr. C. Miller, Chairman Research Ethics Committe[redacted]
DATE:	19 June 1999
PROJECT:	**RECA/99/13 - Morbidity and mortality from road traffic accidents in the UAE and its impact on health care resources in the UAE**

I am happy to report to you that the members of the Research Ethics Committee of the Faculty of Medicine and Health Sciences have approved the ethical principles involved in the above mentioned project.

On behalf of the Committee, I wish you success with this research project.

بسم الله الرحمن الرحيم

UNITED ARAB EMIRATES UNIVERSITY

جامعة الإمارات العربية المتحدة

culty of Medicine & Health Sciences

كلية الطب والعلوم الصحية

Date: 28 April 1999

Director of Al Ain Hospital,
Al-Ain Medical District,
Al-Ain

Dear Sir,

Re: ***Scientific Research Project***

The Department of Community Medicine at the Faculty of Medicine & Health Sciences, UAE University is intending to conduct a retrospective community based study on ***"Morbidity and Mortality resulting from Road Traffic Accidents in the UAE, and its Socio-Economic impact".***

To do this, the department will send Mr. Mohammed El Sadig, to review the medical records of patients reported to ECC and Orthopedic ward at Al Ain hospital during the year 1998 to retrieve the necessary data. The study period will be from 1st to 30th May 1999.

I should be most grateful if you could extend to him every possible assistance to carry out this project.

Yours faithfully,

[redacted]

Chairman,
Community Medicine Dept.
Faculty of Medicine & Health Sciences

Department of Community Medicine
Faculty of Medicine & Health Sciences
UNITED ARAB EMIRATES UNIVERSITY

التاريخ : ٢٨ أبريل ١٩٩٩

سعادة مدير مستشفى العين
منطقة العين الطبية
العيـــن

تحيـــة طيبـــة وبعـــد ، ، ،

الموضوع : __معلومات لمشـــروع بحث علمـــي__

نفيـــدكم علما بأن قسم طب المجتمع بكلية الطب والعلـــوم الصحيـــة ، بجامعـــة العربيـــة المتحدة ، يرغب فـــى القيـــام بـــإجراء دراســـة إسترجاعية عن : " الوفيات والإعاقات الناجمة عـــن حوادث المرور ، والآثـــار الصحيـــة والإجتماعيـــة المترتبة عليها فى دولة الإمارات العربية المتحدة ".

وللحصول على البيانات سوف ينتدب القسم الســـيد / **محمد الصادق حاج أحمد** ، من قسم طب المجتمـــع للإطلاع على سجلات المرضى المراجعين لقســـمي الطوارىء وجراحة العظام بمستشفى العيـــن خـــلال السنة الأخيرة وذلك لإستخلاص البيانات والمعلومات المطلوبة ، وذلك خلال الفـــترة مـــن ١ - ٣٠ مـــايو ١٩٩٩.

وعليه نرجو منكم التكرم بالايعاز لمن يلزم بمساعدته فى تجميع البيانات المطلوبة لإنجاز البحث.

وتفضلوا بقبـــول وافر الشكر والتقدير ، ، ،

أ.د. أويـن للولين للويـد
رئيس قســـم طب المجتمـــع
كـــلية الطـــب والعلـــوم الصحيـــة

APPENDIX (2)

Dubai Ambulance Data Sheet

القيادة العامة لشرطة دبي
الإدارة العامة للخدمات والتجهيزات
إدارة الإسعاف

No. 68000 **Dubai Police General H.Q.**
GENERAL DEPARTMENT OF SERVICES & SUPPLIES
AMBULANCE DEPARTMENT

Date : ____________ التاريخ
Call No : ____________ رقم النداء
Case No. : ____________ رقم الحالة

Shift : المناوبة
A B C D

Timings				الأوقات
Call Recieved	______	AM	PM	وقت الاستدعاء
Ambulance left	______	AM	PM	وقت التحرك
Arrival at location	______	AM	PM	وقت الوصول لمكان الحادث
Left location	______	AM	PM	وقت المغادرة
Arr. at hospital	______	AM	PM	الوصول للمستشفى
Left hospital	______	AM	PM	مغادرة المستشفى
Available for new call	______	AM	PM	جاهز لحالة اخرى

Patient information
Name الاسم : ____________ Sex الجنس ______ Age السن ______
Home address العنوان ____________
Tel الهاتف ____________ Nationality الجنسية ____________
Location of call موقع الحادث ____________
Type of Call نوعية النداء ____________
Nature of call when recieved ____________
طبيعة الحادث عند الطلب

Aid provided before ambulance arrived? هل تم اسعاف المريض قبل وصول الاسعاف؟
☐ None لا يوجد ☐ Yes- Helpful نعم افاد ☐ Yes - Harmful نعم - ضر ☐ CPR تدليك القلب ☐ Splinting تجبير ☐ Controlled bleeding وقف النزيف
☐ Extrication استخرج من مكان ضيق ☐ Shock treatment معالجة صدمة ☐ Medication given اعطي ادوية
By whom? من قبل من؟

Status of patient: حالة المريض

General appearance المظهر العام	☐ Good جيد	☐ Fair معتدل	☐ Poor ضعيف	☐ Critical خطير
Consciousness الوعي	☐ Normal طبيعي	☐ Dazed دوخة	☐ Disoroented مشتت الذهن	☐ Unconscious غائب عن الوعي
Breathing التنفس	☐ Normal طبيعي	☐ Rapid سريع	☐ Labored بصعوبة	☐ Absent لا يوجد
Bleeding النزيف	☐ None لايوجد	☐ Minimum قليل	☐ Moderate معتدل	☐ Severe بشدة
Pain الالم	☐ None لايوجد	☐ Minimum قليل	☐ Moderate معتدل	☐ Severe بشدة
Pulse النبض	☐ Normal طبيعي	☐ Slow بطيء	☐ Rapid سريع	☐ Absent لايوجد
Pupils البؤبؤ	☐ Equal متساوي	☐ Unequal غير متساوي	☐ Constricted متقلص	☐ Dilated متسع
Range of motion الحركة	☐ Normal طبيعي	☐ None below the waist لا توجد تحت الخصر	☐ One side only جهة واحدة فقط	☐ None below neck لاتوجد تحت الرقبة
Skin الجلد	☐ Normal طبيعي	☐ Warm & wet دافىء و مبلل	☐ Hot & dry ساخن و جاف	☐ Cold & clammy بارد و رطب

Nature of injury or illness: طبيعة الاصابة او المرض
Illness code number: ________ رمز المرض
Injury code number ________ رمز الاصابة
Body part injured ________ رمز الجزء المصاب

Vital signs العلامات الحيوية	1	2
Blood presure ضغط الدم	______	______
Pulse النبض	______	______
Respiratin التنفس		

Destination جهة الانتقال
Hospital: ____________ مستشفى
Others: ____________ غيره

Aid provided by ambulance crew: الاجراءات من قبل طاقم الاسعاف
☐ Dry run (code________) بلاغ غير صحيح
☐ Aid given not transported اسعافات اولية بدون نقل
☐ Transported, no aid given نقل بدون اسعافات اولية
☐ CPR تدليك القلب
☐ Airway cleared فتح المجرى الهوائي
☐ Suction شفط بالجهاز
☐ Esophageal airway قطع الحنجرة كمجرى هوائي
☐ Respiratory assisttance استعمال جهاز التنفس
☐ Oxygen اكسجين
☐ Controlled Hemorrhage وقف النزيف
☐ Bandaging تضميد
☐ Anti-shock منع الصدمة
☐ IV fluids سوائل بالوريد
☐ Mast trousers استعمال جبيرة هوائية
☐ Limb splints استعمال جبائر
☐ Defibrillate/Cardiovert اعطاء صدمة كهربائية
☐ Extrication انقاذ من مكان ضيق
☐ Short backboard نقالة العمود الفقري
☐ Psychological support مساعدة معنوية
☐ Restraints التثبيت لمنع الحركة
☐ OB assist / delivery المساعدة على الولادة

Comments and details of aid rendered ملاحظات و توضيح للاجراءات المتخذة

Ambulance crew information تفاصيل طاقم الاسعاف

Name الاسم	Number الرقم	Signature التوقيع
1-		
2-		
3-		

Run conditions ظروف الانتقال

	To scene لمكان الحادث	To Dest. للمستشفى
Lights اللواح	☐	☐
Siren الونان	☐	☐
Severe traffic ازدحام شديد	☐	☐
Mechanical trouble مشاكل ميكانيكية	☐	☐
Communication trouble مشاكل اتصال لاسلكي	☐	☐

I was offered aid by Dubai Police ambulance personnel, but chose not to accept emergency treatment and/or transportation.
Signature: Witness: الشاهد التوقيع
اني رفضت العلاج او/و الانتقال بواسطة مسعفي شرطة دبي بمحض ارادتي

APPENDIX (3)

Data Abstraction Form No. (1)

Department of Community Medicine
Faculty of Medicine & Health Sciences
United Arab Emirates University

The Morbidity & Mortality Resulting from RTA in Al-Ain District

Data Abstraction Form (1)
(Hospital Care Costs)

Serial Number: ☐☐☐☐

A. **Demographic Data:**

1. **Date of the accident** : ------------------------
2. **Time of the Accident**: ------------------------
3. **Nationality** : ------------------------
4. **Sex** : 1. Male 2. Female ☐
5. **Age** : ----------------------

B. ER Report on Casualty Upon Arrival:

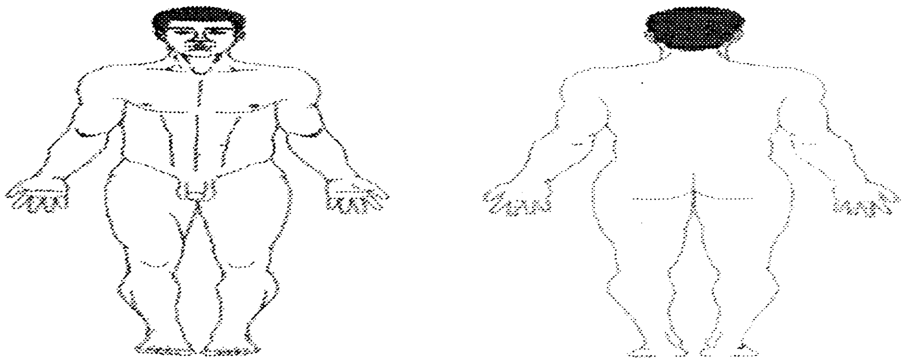
6. **Type of road user** ? ☐
   1. Driver 2. Passenger 3. Pedestrian
   4. Motorcyclist 5. Bicyclist 6. Others
7. **Mode of arrival to hospital**? ☐
   1. Self 2. Police 3. Ambulance
   4. Relatives 5. Others
8. **Condition upon arrival to hospital**: ☐
   1. Conscious (responding to command).
   2. Apprehensive (frightened and disoriented); in pain
   3. Drowsy - bleeding
   4. Unconscious
9. **Pulse Rate :** ---------------
10. **Blood Pressure :** 1. Diastolic: --------- 2. Systolic: ----------
11. **Respiration rate**: ---------------

C. Injury Assessment :

12. **Body-part affected due to the accident**:

☐

IDENTIFY INJURY SITE BY NUMBER



1. Laceration	6. Open fx	11. Edema
2. Abrasion	7. GSW	12. Amputation
3. Hematoma	8. Stab	13. Avulsion
4. Contusion	9. Burn	14. Pain
5. Deformity	10. Cold	

Head:

Maxillofacial:

C-spine/neck:

Chest:

Abdomen:

Perineum:

Musculoskeletal:

13. **Assessment of Injury on AIS:**

	1. None	2. Minor	3. Moderate	4. Serious	5. Severe	6. Fatal
Head and Neck						
Face						
Chest						
Abdomen						
Pelvis						
Extremities						

14. **Principal Diagnoses** *(Physician judgement of case severity):*

----

15. **Investigation** : ☐

1. None
2. Basic
3. Advanced

16. **Intervention** : ☐

1. Advice
2. Basic
3. Special

17. **Outcome** : ☐

1. Discharged home
2. Admitted to the ICU
3. Admitted to ward
4. Transferred to other hospital
5. Dead

D. Intensive Care Unit (ICU):

18. **Date of Admission:** ------------------------

19. **Number of Days in the ICU:** ------------------------

20. **Treatment at ICU:**

	Basic	Advanced	Special
Investigation			
Procedure			

21. **Intervention at ICU:** ☐
1. Conservative
2. Operative

22. **Outcome**: ☐
1. Dead
2. Transferred to the ward
3. Transferred to other hospital

E. Hospital Ward:

23. **Date of Admission / Transfer:** -------------------------

24. Treatment in the ward:

	Basic	Advanced	Special
Investigation			
Procedure			

25. **Intervention in the ward:** ☐
1. Conservative
2. Operative

26. **Outcome:**
1. Discharge Date : ------------------------
2. Transfer Date : -------------------------
3. Dead: ----------------------------

27. **Complications**:

1. Yes 2. No
If Yes :

----

28. **Percentage Loss in Overall Functional Capacity:** ☐

1. Total (70 - 90%)
2. Severe (50 - 70%)
3. Serious (30 - 50%)
3. Moderate (10 - 30%)
4. Mild (5 - 10%)
5. None 0%

APPENDIX (4)

Data Abstraction Form No. (2)

Department of Community Medicine
Faculty of Medicine & Health Sciences
United Arab Emirates University

The Morbidity & Mortality Resulting from RTA Trauma in Al-Ain District

Data Abstraction Form (2)

ER Number: . ☐☐☐☐☐☐

Hospital No. ☐☐☐☐☐☐

A. Descriptive Data:

1. **Date of the accident:** ------------------------
2. **Time of the Accident:** ------------------------
3. **Nationality:** ------------------------
4. **Sex :** 1. **Male** 2. **Female**
5. **Age :** ------------------------
6. **Location:** 1. **City/Town** 2. **Country**
7. **Type of Road:** 1. **Dual carriage (highway)** 2. **Single road**

B. Injury Pattern:

8. **Injury Mechanism:**
   1. RTA 2. Fall from height (specify height) ------------
   3. Assault 4. Work injury 5. Sports injury
   6. Home Injury 7. Camel riders
   8. Others (Specify) ------------------------------

9. **Type of road user?**
   1. Driver 2. Front Seat Passenger 3. Back seat passenger
   4. Pedestrian 5. Motorcyclist 6. Bicyclist
   7. Others

10. **Safety Devices (restraints):**
   a. 1. No seat belt applied 2. Seat belt applied
   3. Helmet 4. No helmet
   b. 1. Airbag 2. No Airbag

11. **Type of Vehicle:**
   1. Saloon 2. 4WD 3. Pickup
   4. Truck 5. Bus 6. Others (Specify) ----------------

12. **Mode of Accident:**
   1. Head on collision 2. Hit from behind 3. Hit from side
   4. Hit fixed Object (barriers/trees/wall/others) 5. Turnover
   6. Tire burst 7. Hit by camel 8. Others

C. ER Report upon arrival to Hospital:

12. **Condition of the patient:**

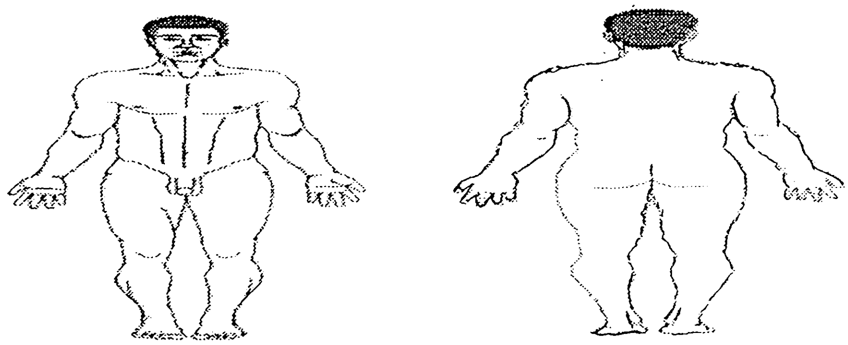
1. Conscious (responding to command).
2. Apprehensive (frightened and disoriented); in pain
3. Drowsy - bleeding
4. Unconscious

13 **Vital Signs:**

a. Pulse Rate : ---------------
b. Blood Pressure : 1. Systolic: ---------- 2. Diastolic: ---------
c. Respiration rate: ----------------
d. Temperature: ----------------

14. **Body Part affected due to the accident:**

IDENTIFY INJURY SITE BY NUMBER



1. Laceration
2. Abrasion
3. Hematoma
4. Contusion
5. Deformity
6. Open fx
7. GSW
8. Stab.
9. Burn
10. Cold
11. Adema
12. Amputation
13. Avulsion
14. Pain

Head

Maxillofacial

C-spine/neck

Chest

Abdomen

Perineum

Musculoskeletal

----

18. **Investigation**:

1. None
2. Basic
3. Advanced

19. **Speciality involved:**

----

20. **Intervention**:

1. Advice
2. Basic
3. Special

21. **Outcome**:

1. Discharged home
2. Admitted to the ICU
3. Admitted to ward
4. Transferred to other hospital
5. Dead

22. **Severity of Injury on AIS:**

	1. None	**2. Minor**	**3. Moderate**	**4. Serious**	**5. Severe**	**6. Fatal**
Head and Neck						
Face						
Chest						
Abdomen						
Pelvis						
Extremities						

D. *Intensive Care Unit (ICU):*

23. **Date of Admission**: ------------------- Date of discharge/transfer:--------

24. **Number of Days in the ICU**: -------------------------

25. **Treatment at ICU:**
    1. Basic
    2. Special (Specify) --------------

26. **Outcome**:
    1. Dead
    2. Transferred to the ward
    3. Transferred to other hospital

E. *Hospital Ward:*

27. **Date of Admission / Transfer:** --------------------------

28. **Investigation**

    1. Basic
    2. Special (Specify) -------------

29.Final Diagnosis

----

30. Treatment in the ward:
1. Conservative (Comment if any)
2. Operative

31. Operation
a. Date of Operation
b. Type of operation
c. Post-op Complication
d. Other Comments

32. Outcome:
1. Discharge Date : -------------------------
2. Transfer
3. Dead:

33. **Complications**:
1. Yes 2. No

If Yes :

APPENDIX (5)

A copy of a Paper by the Author entitled:

El-Sadig M, Nelson Norman J, Lloyd O L, Romilly P, Bener A. Road Traffic Accidents in the United Arab Emirates: Trends of Morbidity and Mortality during 1977-1998. 2002. *J. Accidents Analysis and Prevention.* Vol. 34 (4): 61-72.

APPENDIX (5)

A copy of a Paper by the Author entitled:

El-Sadig M, Nelson Norman J, Lloyd O L, Romilly P, Bener A. Road Traffic Accidents in the United Arab Emirates: Trends of Morbidity and Mortality during 1977-1998. 2002. *J. Accidents Analysis and Prevention.* Vol. 34 (4): 61-72.

APPENDIX (6)

Certificate in Principles of Epidemiology by the CDC, 1996.

DISTANCE LEARNING PROGRAM

THIS CERTIFICATE IS AWARDED TO

MOHAMMED HAJ AHMED

HAVING SATISFACTORILY COMPLETED A

SELF-INSTRUCTIONAL COURSE IN

PRINCIPLES OF EPIDEMIOLOGY

CEU 3.5

Sponsored by the
PUBLIC HEALTH PRACTICE PROGRAM OFFICE

Date: August 15, 1996

[redacted]
DIRECTOR, DIVISION OF MEDIA AND TRAINING SERVICES

[redacted]
DIRECTOR, PUBLIC HEALTH PRACTICE PROGRAM OFFICE

U.S.DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service

CDC

APPENDIX (7)

Certificate on Safety Promotion Research from Karolinska Institute, 1999.

KONGL CAROLINSKA MEDICO CHIRURGISKA INSTITUTET

CERTIFICATE

Mohammed El Sadig Haj Ahmed

Has completed and passed this course

2ND INTERNATIONAL PHD COURSE ON SAFETY PROMOTION
RESEARCH: A PUBLIC HEALTH APPROACH TO ACCIDENT
AND INJURY PREVENTION

worth 2 credit points

Autumn 1999

The course was provided by
Karolinska Institutet
Department of Public Health Sciences
Division of Social Medicine

October 199[redacted]

[redacted]

Lucie Laflamme, PhD, Associate Professor
Course Leader

Leif Sv[redacted]or
Course Leader

APPENDIX (8)

The Consumer Price Index and the General Interest Rate in the UAE
(1985-1996)

Appendix (8)

The Consumer Price Index (CPI) and the General Interest Rate in the UAE (1985-1996)

Year	CPI/UAE	CPI/Year	CPI % Change	G. Interest Rate	Adj. Int. Rate
1985	100.0	0	0	5.5	5.5
1986	102.1	2.1	0.021	5.8	5.568
1987	104.2	2.1	0.021	6.1	5.856
1988	105.2	5.2	0.052	5.4	5.119
1989	108.7	3.5	0.035	4.3	4.149
1990	109.4	1.7	0.017	6.7	6.521
1991	115.4	6	0.06	6.2	5.828
1992	123.6	8.2	0.082	5.4	5.184
1993	129.5	4.2	0.042	4.8	4.608
1994	135.6	6.1	0.061	5.1	4.896
1995	141.5	5.9	0.059	4.7	4.512
1996	146.1	4.6	0.046	5.6	5.376
Mean		4.13	0.041	5.46	5.25975
SD		2.34	0.023	0.72	0.66